THE DESIGN OF
FACTORY AND INDUSTRIAL BUILDINGS

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THE DESIGN OF FACTORY AND INDUSTRIAL BUILDINGS

WITH CHAPTERS ON WELFARE WORK AND INDUSTRIAL RESEARCH DEPARTMENTS

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WITH 98 ILLUSTRATIONS AND EXPLANATORY DIAGRAMS

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PREFACE.

During the past four years the erection of factory buildings has been the chief source of work for the building trade of this country, and it might be assumed that the supply of industrial buildings will be equal to, if not greater than, any demand that is likely to be made in the immediate future.

This may be true of works connected with the engineering and allied trades, but it should be remembered that many trades having little direct connection with munition work have been almost idle during the "War period," and with the return of normal conditions and the opening of new markets an expansion of their output is certain.

The advantages that have accrued to firms possessing works planned for the purposes for which they are used has caused many employers to realize the urgent need of a reconstruction of their own premises, and if a new era of prosperity is to be the aftermath of the War, the reconstruction of existing premises, or the erection of entirely new works, will in many cases be a necessity for the progressive firm or corporation.

The absence of a short book dealing with modern factory design has been for long remarked upon by architects, manufacturers, and many persons connected with industrial buildings, and whilst most classes of structures can boast several volumes devoted to their construction and development, the factory, which is the cradle of industrial supremacy, has been almost neglected.

In the preparation of the book the author has endeavoured to give but the essential principles governing the design of this class of buildings, as the detail questions of construction involved have been fully dealt with in other publications or are already familiar to the reader.

Thanks are due to the authors and users of the various buildings illustrated and described, and especially to J. Alban Scott, Esq., for permission to reproduce Fig. 12, on page 29, from his work "Reinforced Concrete in Practice," which will be of great assistance to architects using this form of construction in the course of their practice.

Acknowledgment must also be made to "Concrete and Constructional Engineering" for permission to quote from various articles which have appeared in that magazine.

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13 John Street, Adelphi,
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CHAPTER I.

GENERAL CONDITIONS RELATIVE TO FACTORY AND INDUSTRIAL BUILDINGS—THE CHANGED OUTLOOK OWING TO THE WAR—SPEEDING UP OF PRODUCTION AND THE INTRODUCTION OF WELFARE WORK.

THE point of view from which the design of factories and industrial buildings is approached has greatly changed during the past few years.

This change has been brought about by three causes: More thorough organization, the influence of Factory Acts legislation and building bye-laws, and the spread and influence of Welfare Work.

Previous to 1914 progress was relatively slow, and although it was beginning to be realized that a building planned for the work to be carried out in it led to increased production, the average employer of labour looked askance at all factory legislation. Welfare work as now understood was assumed to be a subject interesting for discussion by University Extension lecturers and similar bodies, but far too Utopian to be dreamed of as a part of the normal factory development.

The firms that made a study of the welfare of their workers were the exception, and when the creation of centres such as Bournville, Port Sunlight, or York was discussed, the consensus of opinion seemed to be that such treatment of the workers would, if universally introduced, lead to such bankruptcy of national industries that foreign manufacturers would capture all our markets.

To-day, on the contrary, welfare work has become a normal part of the factory organization, and the larger firms are now vying with each other in the advantages that they can provide for their employees.

But to return to the factory itself; the immense orders placed by Government departments for munitions of war, the control of

works, and the speeding up of production have caused the employer to see that the old-fashioned type of building with additional rooms or blocks added just as they were needed at the time cannot but impede the speedy production of goods, and has led him in many cases to throw overboard his old prejudices and start afresh as far as building conditions in war time will allow him.

Apropos of this, Mr. Asquith in his speech at the Mansion House on 3 August, 1916, fully expressed these facts when he said: "A large number of British industries have shown extraordinary enterprise and resourcefulness since the war broke out . . . calling in all the available and mechanical resources of the country for the purpose of increasing output and improving organization. In certain trades, I am told, and I am sure it is true, already changes have taken place which amount to a positive revolution, and there is scarcely an industry in this country which has come out of the ordeal of war without being braced and stimulated by the special difficulties that had to be surmounted."

Since this speech was made thousands of workers have been withdrawn from the ranks of labour, but in spite of this the nation has become more self-supporting, trade has expanded, and industry become more intensive and productive.

The old saying that "John Bull is asleep and will never wake up" has been given the lie, and the close of the war will find industry fully awake to the possibilities that lie before it. In this renaissance of industry the worker will insist upon better working conditions, and when the manufacturer, realizing this, also realizes that modern buildings will give him an advantage over competitors working in out-of-date structures, the rebuilding and reconstruction of factories will become as much a necessity as the introduction of the latest labour-saving devices.

The out-of-date factory consisted of a space enclosed by walls, here and there pierced with small windows. Piers sometimes projected externally, but often, on the contrary, into the rooms, with the result that a long row of machines had to be placed so much further in from the walls as the piers projected. Columns and supporting piers were placed without any regard to the use of the structure, and in such a building the maximum of production could not take place with the minimum of cost.

Against this let us set the factory of the future, which will be planned to suit the requirements of the trade to be carried out therein, and as analysis of expenditure proves that standardization applies to building as well as to manufacturing, the general design known as

the "Unit" system will become, as far as the site allows it, a *sine qua non* of a successful enterprise.

With this will be incorporated the provision of the maximum daylight surface, for here again analysis of expenditure would often prove that the cost of providing sufficient artificial light has added in the past an appreciable percentage to the cost of the goods manufactured.

Another lesson that the war has taught and impressed upon the manufacturer is that successful organization, supervision, and co-ordination of work can only be effected where one department is placed in proper relationship to the others, and where the possibility of extension is allowed for.

In the past many a building was arranged in which each department was in proper relationship to its fellows, and occupied the floor area that it required; and all was well so long as business was normal and annual production kept to the same level. When, however, trade expanded one department encroached upon another, sheds or blocks of buildings were added as they were needed, but without any settled idea as to where the next addition would be placed; and to-day the result is chaotic.

It is very rare for a manufacturer to desire his turnover in ten years' time to be what it is to-day, and if, as is frequently stated, the future will be in the hands of the large firms and corporations, it behoves all manufacturers thinking of erecting works to look five or ten years ahead, and to have a general scheme prepared that will provide for extensions and at the same time allow space for unforeseen developments that may take place.

By plotting on squared paper the business done for the past few years, making such allowances as can be assumed, a fairly reasonable idea can be gained as to future needs, and where the new structure is of standardized unit bays, machinery and shafting can be moved forward into the new spaces and still occupy the same relative position in the building.

Where such a general scheme is prepared the bays at once required can be straightway erected, and where extension will be made the last piers built to receive the future load and the spaces between filled in with the lightest walls allowable that will keep out the weather.

The results of such general plan will often save many heavy future expenses; for example, heating chambers will be built large enough to receive future boilers necessary, and stairs and escape ways will not be built where lines of shafting and communication will be required.

Many such mistakes are met with and could be adduced as evidence, but the following will be sufficient.

In the first case a factory was built adjoining vacant land upon which an option was secured. A brick-enclosed escape stairs was built abutting on rear wall, and when the inevitable extension occurred these stairs would have occupied a space in the centre of the whole block and have interfered with supervision. The result was that a few years after the building of the first block these stairs had to be pulled down and re-erected on the side wall only 40 ft. from their original position.

In the second case drains for front building were laid close to surface, and when the rear building was erected the drains had to be taken up and re-laid at a deeper level at a cost of several hundred pounds, quite apart from the fact that access along side roadway leading to works was interfered with.

Whilst dealing with the question of extensions, it may be wisely pointed out that if possible allowance should be made for placing the canteen and other welfare buildings, the research building, and often the administrative block outside the factory proper.

When canteens were first introduced they were often placed in some vacant corner of the works, and under such conditions convenience of working them was perforce difficult.

To-day they are still often designed and placed in the building and in proper relationship to the workers, but there is no doubt that the ideal position for them is outside but near to the building itself.

The increasing provision of rest-rooms, games-rooms, and libraries, in addition to the dining-room, and the extending use of such rooms by employees after working hours is tending to evolve a new type of Workers' Club, and such a building must be placed outside and entirely cut off from the manufacturing part of the building.

The ideal position is therefore adjacent to the factory but close to the public road, and direct exits should be provided to the latter.

To a certain extent the same remarks apply to the research and laboratory buildings in which experiments requiring freedom from vibration and occupying many hours or days may be carried out. It is not always convenient for the main building to be kept open until the research worker has finished some lengthy experiment, and these reasons alone point out the necessity of making them distinct structures.

Working Floor Area of Factory in Sup. Feet.	4-Story Factory, 30 Feet Wide, Inside Dimension.	5-Story Factory, 50 Feet Wide, Inside Dimension.	Single Story, Weaver Shed Roof.	Single Story with Gallery.
5,000	100	—	75	95
10,000	—	97	75	90
25,000	—	94	70	88
50,000	—	87	63	82
100,000	—	82	61	70

FIG. 1.—Percentage costs of various types of factories.

CHAPTER II.

THE MAIN TYPES OF INDUSTRIAL BUILDINGS.

BEFORE turning to the consideration of the site and building, it will be useful to review the types of structures that are used for industrial structures, for although sometimes two types may be equally suitable, that selected will have an influence on the choice of the site.

Buildings for industrial purposes may be divided into the following main classes:—

1. The building of several stories.
2. The single story building generally roofed with weaver-type principals and top lighted.
3. The single story as above but with galleries around the walls.
4. The machine shop type of structure used for heavy engineering works, shipbuilding yards, etc.
5. The specialist type of building, such as bakeries, silos gasworks, etc.
6. The store and warehouse building.
7. The research building.
8. Canteens and general welfare buildings.

The above classes could be still further subdivided, but such grouping will be sufficient for our purpose, and this volume deals exclusively with classes 1, 2, 3, 6, 7, and 8, for buildings comprised under classes 4 and 5 raise problems that cannot be dealt with in a general manner or in such a small compass as this book allows.

General Considerations of Classes 1, 2, and 3.—The building of several stories was almost universal until twenty years ago, when the influence of American ideas gave a great impetus to the erection of single story buildings which could be controlled from an office raised several steps above the floor and known to the workers as the "lighthouse".

The difficulty of moving goods from one floor of the building to another and the vibration set up by machinery played a great part

in popularizing the single story structure, but the introduction of lifts giving easy access from one floor to another and capable of taking comparatively heavy weights has solved the first difficulty.

As to the question of vibration; modern methods of construction have reduced this to a minimum. Opinions still differ as to whether the most delicate operations can be carried out in buildings portions of which are subjected to violent shocks from heavy machines, but if sufficient care is taken in the design of the structure most industries can be carried on as well in a building of several stories as in one of a single story.

Where the factory is situated in the heart of a manufacturing town the cost of the land will favour the several story building, whilst in the country, where land is cheap, the tendency will be towards a single story building with perhaps a gallery around the walls.

This last type is, reduced to its elements, the single story built with greater height to the underside of its principals and with a gallery around its walls. It is common in aeroplane works and in factories where a number of parts are made at the sides and come together in the centre for assembly.

The whole of the supports should be in the external walls and at the edge of gallery, leaving the centre quite free of obstructions. This can be arranged where distances between the galleries do not exceed 80 ft. by forming the roof principals in the web of lattice girders or resting on deep beams.

As regards the comparative cost of the three types of structure the table (Fig. 1) above gives an analysis of typical buildings of each class based on prices current in 1914.

The factories were 30 and 50 ft. wide for the several story buildings and twice the depth of frontage for the single and galleried ones, the galleries being 20 ft. wide in all cases.

For buildings of several stories, floors were all 14 ft. floor to floor with roof over top story, as shown in Fig. 2.

For single story buildings the height from floor, the underside tie of principals was 12 ft. 6 ins. and span of principals about 20 ft. For galleried buildings the height from floor to floor of gallery was 13 ft. and from gallery to tie of principals 12 ft., the span being as for the single story.

Buildings were calculated for as having brick walls, concrete floors, and steel construction for stancheons, beams, and principals.

In the table a figure of 100 is taken to represent the most expensive of the three groups, and the relative costs are expressed in percentages of this.

Where the building of several stories is used, the possibility of future extensions may be met by designing it for the full number of floors that may ultimately be required, putting in foundations and piers strong enough for these, and building the walls of the stories now erected of the thicknesses that may be required for the final structure.

Where this plan is adopted the supporting members should be carried up to or even through roof and prepared for the next addition, i.e. stancheons should not finish below girders, so that these may have to be cut and bracketed to the stancheons they were resting upon.

If the roof is made flat this will, with slight alterations where falls occur, form the basis of the future floor.

Where the staircases are already carried up to the roof it is possible by the use of outside gantries to erect the new floors without interfering with the use of the building below, as connections to pipes, vents, flues, etc., can be made during the hours that the works are unoccupied.

Such method of construction of course greatly increases the price of the first building, but such expense is outweighed by the advantage to the manufacturer who realizes that extensions can be carried out with but little inconvenience to his business.

There are, however, several points that call for attention in this procedure, viz.:—

1. If, as in London, the cubic contents allowed for any structure are limited, division walls must be placed so that in the completed building no block will exceed the maximum permitted. As an example: Under the London Building Act (1894), buildings of the warehouse class are limited to a capacity of 250,000 cub. ft. unless divided into sections by brick walls.

Openings may, it is true, be made in these walls to connect the several blocks, but such openings are limited in size, and must be fitted with fire-resisting doors.

By the Amendment Act (1910) the possibility of buildings having a cubic capacity beyond 250,000 cub. ft. is provided for in certain cases, but a limit in height of 60 ft. is inserted, and such consent generally carries with it a large number of special requisitions.

If, therefore, a scheme is prepared in which the final building will extend beyond the maximum allowed cubic capacity, and only the lower floors are to be at once erected, all calculations must be made for the completed structure and the necessary cross walls built.

2. Staircases must also be arranged for the number of persons

that will finally use the buildings, and this applies especially to the escape staircases and exit ways.

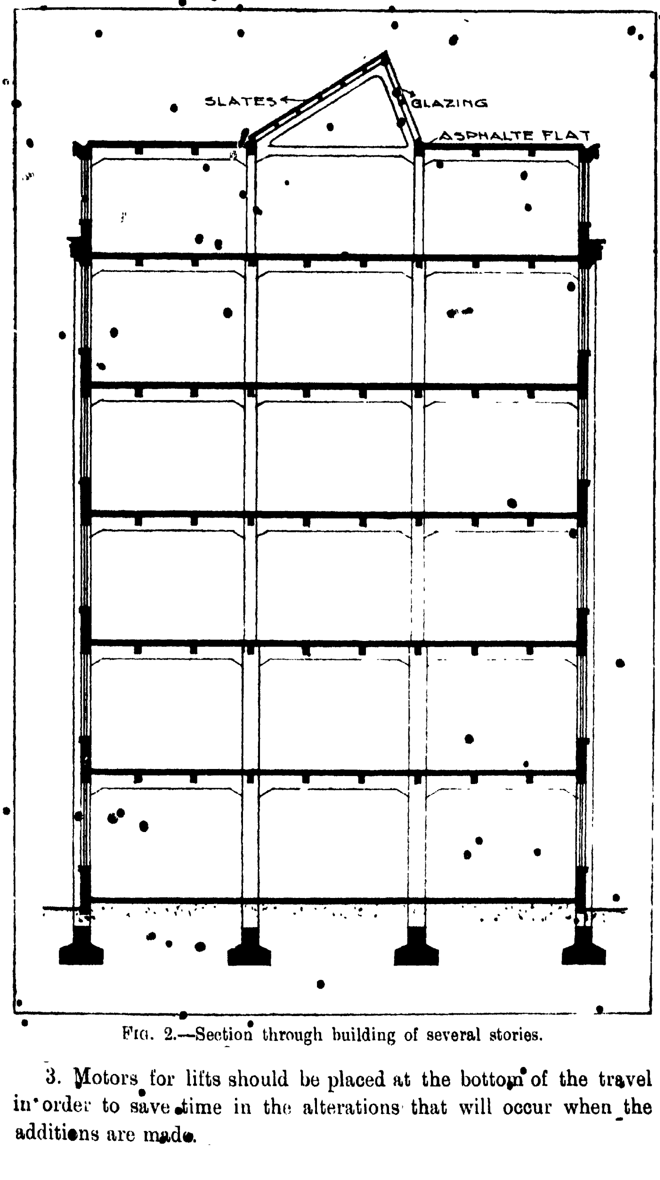


FIG. 2.—Section through building of several stories.

3. Motors for lifts should be placed at the bottom of the travel in order to save time in the alterations that will occur when the additions are made.

It may be taken as a very safe rule to consult the officials administering the Building Acts and Bye Laws of the district before the plans are far advanced, and this is especially necessary in the cases mentioned above. The writer has always found the officials of the L.C.C. and other Councils most obliging and willing to help in overcoming difficulties that may arise, and the advice given has often saved much time in the preparation of the final working drawings.

Advantages and Disadvantages of Classes 1, 2, and 3.—The following is a summary of the advantages and disadvantages of each class of structure:—

The building of several stories.

Its chief advantages are:—

1. Large floor area can be provided on a relatively small site.

2. Any part of building can be reached in a shorter time than in a single story structure.

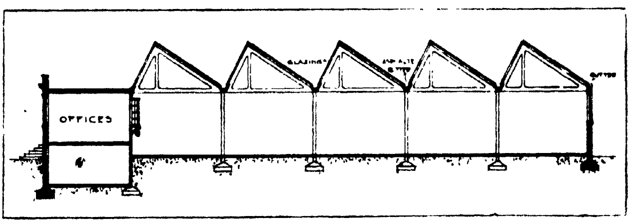


FIG. 3.—The single story building.

Its disadvantages are:—

1. Top lighting can only be provided for the topmost story.

2. Where heavy machinery is used vibration may occur that will interfere with delicate operations.

3. Placing of machinery is controlled by the necessary supports more than in single story structures.

4. Its width is limited by the distance natural light will carry.

5. If the building is small an appreciable percentage of floor area will be lost in lifts, staircases, escape-ways, etc.

The single story building.

Its advantages are:—

1. A uniform light can be obtained over the whole area.

2. An office raised several steps above the general floor level will give supervision over the whole building.

3. Less supports are needed as by forming principals in the web of lattice girders or on deep beams factories up to 60 ft. wide can be easily built without supports, and factories up to 150 ft. by 100 ft. can be arranged with but one central pier (see Fig. 9).

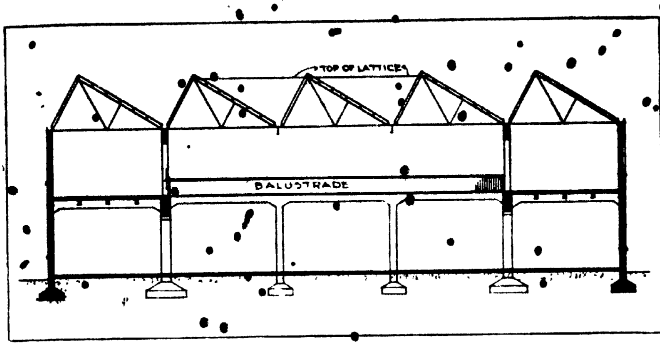


FIG. 4.—The gallery factory.

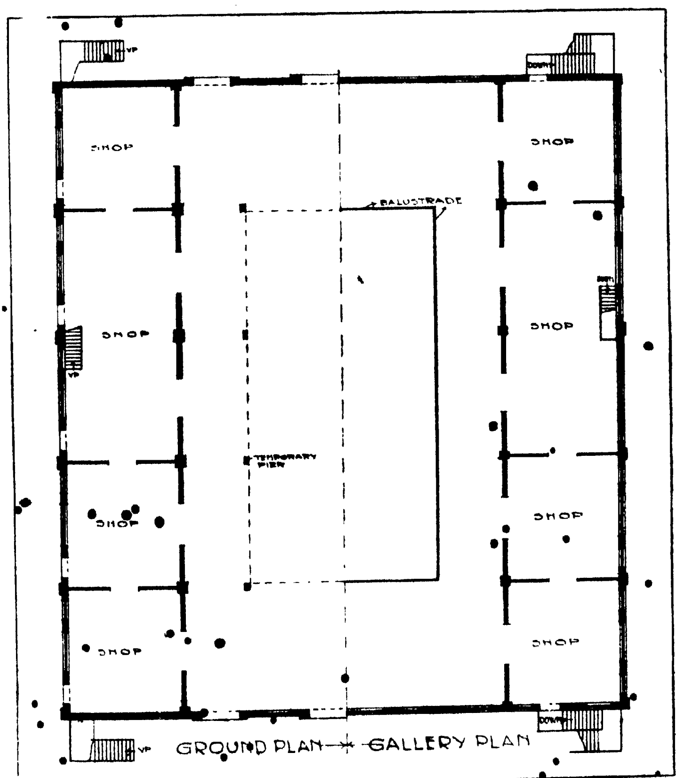


FIG. 5.—Diagram plan of gallery factory.

Its disadvantages are:—

1. Owing to the area covered, more time is spent in passing from one part to another.

2. The large amount of guttering required and the difficulty of keeping it clean, especially in districts where heavy falls of snow occur.

3. The arrangement of shafting is somewhat more difficult than in the building of several stories.

4. The cost of heating and ventilating is more expensive than in the building of several stories.

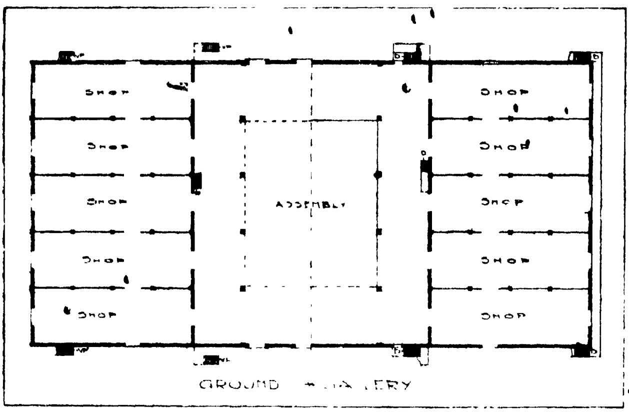


FIG. 5A.—Diagram of gallery factory (extended).

The single story with gallery.

Being a development of the single story building and at the same time possessing features of the storied structure, it has some of the advantages and disadvantages of the two former classes.

It is, however, admirably suited for works where a number of relatively small sections come together to be assembled into a large body in the centre, and although at first it might appear as not being capable of extension, Figs. 5 and 5A show how this can be effected.

CHAPTER III.

THE SITE AND THE PLACING OF THE BUILDINGS AND ITS ADJUNCTS UPON IT.

In the choice of the site for new works the manufacturer will generally be tied as to the district where they are to be placed, and in any case railway, road, and perhaps water transport will be factors that must be considered.

It however sometimes happens that a firm will decide to leave their district and settle in the country, and where such decision is made, questions as to proper housing of the workers, drainage, power, and lighting become paramount considerations that cannot be lightly dismissed. Power and lighting can of course be easily arranged, but the provision of housing and drainage may involve a greater expenditure than that of the works themselves. To place a large manufacturing plant in the heart of the country-side, perhaps several miles from a town, may involve the firm in building a village or even a small town. Not only must the workers be housed but the education of their children must be considered, shops must be provided, and the provision of all the means of giving the facilities of civilization arranged for.

In such a case common sense would cause the firm to commission their professional advisers to work out the possibilities of the site before negotiations for its purchase were completed, and similar procedure should be general in the case of any building.

Almost invariably a level site is required, and when sites are being considered it should be remembered that the cost of removing surplus soil on a sloping or irregular site may involve an expenditure equal to or greater than that of the site itself.

The nature of the soil and subsoil are also important, for as is well known the foundation work is far from being a negligible proportion of the total cost of the building, and trial holes should in doubtful cases always be sunk; also, no site should be chosen that is liable to flooding even if the risk is very slight. Where site is contained by

retaining walls these should be thoroughly examined, and if possible the responsibility of failure during a period placed on the vendor.

If, however, no risk of flooding occurs, a site that is damp or near marshy ground should be avoided, for not only will it affect the health of the workers and tend to damage machinery and plant, but in most cases the cost of foundation will be greatly increased.

Where boilers, etc., have to be sunk below normal floor level, and where heavy concrete beds have to be formed for machinery, the presence of water in the trial holes should generally eliminate the site from consideration, as either an abnormal amount must be spent on foundation and waterproofing work, or the floor of the factory must be raised above general ground level.

The best foundations are gravel and rock, and with the latter all pockets must be filled with concrete, and in most cases a certain amount of step levelling is necessary. Sandy gravel is good, but care should always be taken in dealing with sand to eliminate any chance of it being washed away. Clay is damp and will generally lead to settlements, however deep the foundations may be carried, and the same remark applies to made-up ground, for however long it may have stood dangers of subsidence occur, and as settlement of one pier may throw a long line of shafting out of action and lead to heavy expenses, the provision of a raft over the whole of the surface of the factory is to be desired in the above cases. The formation of inverted T beam carrying all piers, and the filling in of intermediate spaces with reinforced concrete slabs makes a monolithic foundation for the whole structure, and is sometimes much cheaper than forming separate foundations for each pier.

Another matter that may exercise a considerable influence is the possibility of obtaining easy transport of the building material required, and this may be the factor that will decide whether the building shall be of steel frame or reinforced concrete construction. When sand and gravel suitable for the aggregate are on the site or close at hand, the employment of the latter will generally be found to be most economical.

The question of the site having been briefly considered, we now turn to the placing of the buildings upon it.

Before, however, any sketch drawings are prepared, the designer should (if possible with the manufacturer or works manager) visit factories carrying out work similar to that for which the factory is being designed, and at the same time a schedule should be prepared which will embody all the information for working out the complete scheme.

This schedule will be drawn up for both the present and final future extended use of the factory, and will comprise :—

1. Number of workers, male and female, for each department.
2. Number, description, and over-all size of machines.
3. Size and details of gangways, etc.
4. Position of inspection rooms.
5. Size, number, and position of stores.
6. Full description of receiving, sampling, packing, and despatch rooms.
7. Particulars of foreman's and check offices.

Where any of the departments treated in this volume as the adjuncts of the factory are required to be in the building itself, full details of them will be appended to the above list.

Following on this schedule should be notes or description of the system on which the factory will be worked, and although every business has its own general methods of organization, broadly speaking the systems in use are few in number.

As an example: In the manufacture of boots, the leather for the making of the uppers is cut by clickers and then passes to the closing room where the pieces are stitched together. Coming from this department it meets the heavy sole leathers from rough-stuff room, and thence passes through lasting, soling, heeling, and finishing machine rooms, and leaving this last department, the boots pass into the spaces allotted for drying, packing, and despatching.

Against this may be set the system in vogue in many engineering works, where various departments deal with the separate parts and finish them off so that they first meet together in the assembly shop.

From the schedule and notes above referred to, together with the observations made in other works, the architect will prepare sketch plans which should be analysed and discussed with the manufacturer, works manager, and chiefs of each department. These consultations will often eliminate mistakes that would cause heavy expenses in alterations after the building work is commenced.

In the preparation of these plans the size of the unit on which the building is to be designed will be controlled by the most important machines and the necessary gangways. By this term unit is meant that centres of all columns, piers, and supports are placed at equal distances from each other, both longitudinally and transversely. This does not mean that every bay must be square or even rectangular, for on some sites a rhomboidal unit will be found best, but endeavour should be made to make x.x.x. and y.y.y. equal to each other throughout (see Fig. 6).

The standardization of each unit will tend to economy in building, for it will be readily realized that not only are a great number of the beams, stancheons, etc., of same length and often of same section, but principals, frames, and sashes become units or multiples of similar sizes, and the works engineer will also greatly appreciate this, as in the future use of the building shafting can be standardized and made interchangeable.

In the choice of the size of the unit, dimensions of from 16 to 25 ft. have been found most economical. Larger bays may of course be easily constructed, but it should be remembered that wide bays mean deep beams, and these will often interfere with the natural lighting and the arrangement of shafting.

The whole factory having been arranged on a series of unit bays the arrangement of departments must next be settled.

The assistance of the works manager is here necessary, and the

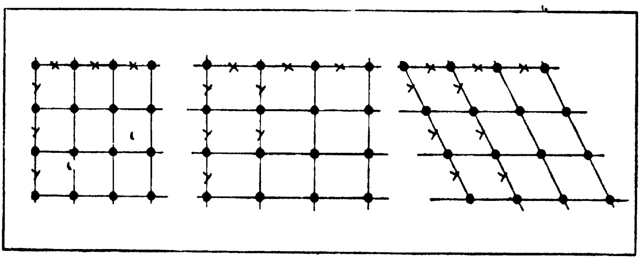


FIG. 6.

essential point to remember is that the direction or lines of processes should not clash or cross each other. A natural growth of the product should take place from its raw to its finished state, and an arrangement of a factory as shown in Fig. 7 is the ideal to be striven for.

The Adjuncts of the Factory.—These tend to take up a greater proportion of space from year to year, but many of them can often be arranged to occupy the corners and angles of an irregular site, thus leaving the workrooms of regular shape.

Unless absolutely necessary, staircases, lifts, lavatories, and all subsidiary rooms should be placed outside the containing walls of the manufacturing portion of the factory, and piers should project outward rather than into the building.

The special requirements of these departments will be more fully dealt with in the following chapters, but these notes will be of use in plotting their position in the general scheme.

The Offices if placed in a separate building should be close to the factory itself, and staircases should be planned so that it is not needful to traverse a portion of the works to get to an upper floor.

The Raw Material Store is often a part of the factory itself, but if it forms a separate building or sheds it should be placed so that the material can be taken into the works without interfering with the delivery of other stores into the building.

The Power House.—The majority of factories are now supplied with gas or electric power from company's mains, and the increasing

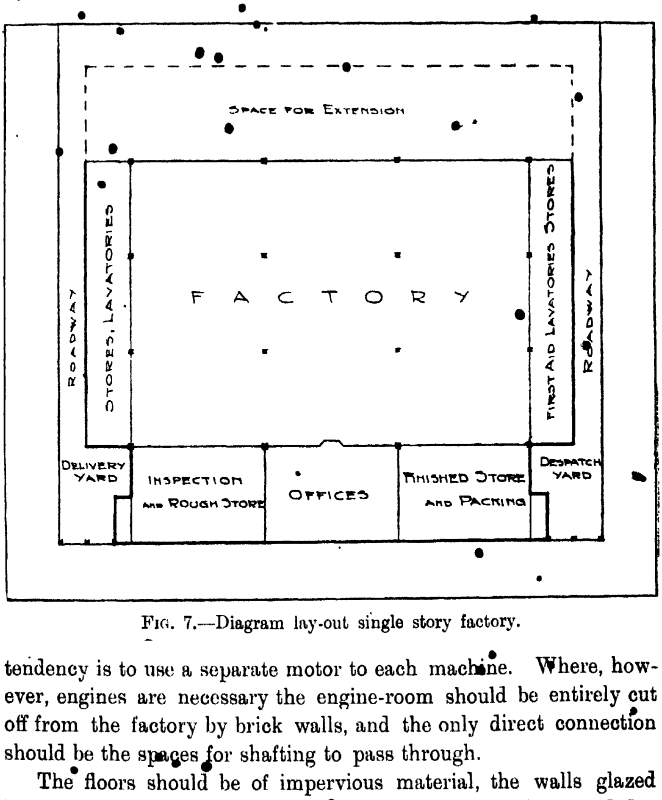


FIG. 7.—Diagram lay-out single story factory.

tendency is to use a separate motor to each machine. Where, however, engines are necessary the engine-room should be entirely cut off from the factory by brick walls, and the only direct connection should be the spaces for shafting to pass through.

The floors should be of impervious material, the walls glazed brick, and large windows giving abundant light should be provided.

Showrooms.—Where these occur in connection with works they should be placed in close conjunction with the offices and at the same time adjoining or near to the despatch department.

Lighting should be carefully considered for this department, and

everything done that will show the goods manufactured to the best advantage.

The Research Department.—This will be dealt with in Chapter X., but the following notes should be remembered :—

1. Abundance of light (preferably north light) should be provided.
2. It should be insulated from the vibration of the factory.
3. Easy access to both factory and offices should be arranged.

The Sanitary Arrangements.—These should be placed outside the factory. Some firms prefer to make them distinct structures cut off by a road or open space from the main building and approached on the upper floors by bridges. This is doubtless the ideal arrange-

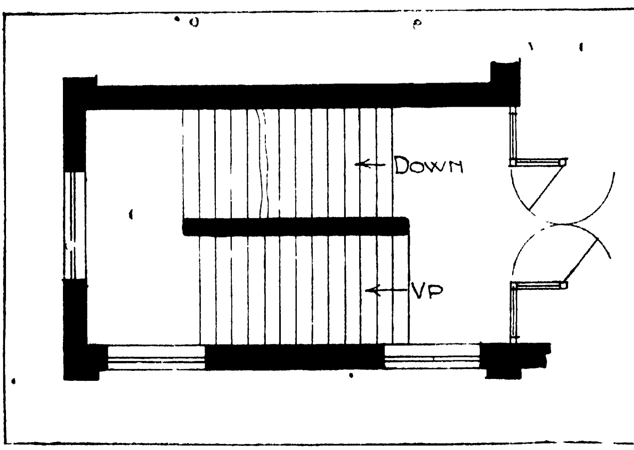


Fig. 8.

ment, but where it is impossible, well-ventilated lobbies should always be placed between the sanitary and manufacturing departments of the building. Where the number of the workers reaches eighty or over, it will be found economical to place an attendant in charge of the lavatory block, whose duties will be to check the time in and out, to control water supplies, and to keep fittings clean. If lockers are provided, as is becoming more and more the rule, then the attendant's office should be placed to also control these.

The First-Aid Room.—The necessity of this department is at once apparent to anyone who has spent much time in factories; for whatever care may be taken and whatever safety devices may be installed, accidents are sure to occur. The position of the first-aid

room should be near and fairly central to the whole works, but should be cut off from the factory proper by a lobby, and provision made for removing stretcher cases after attention without taking the patient through the factory.

Where the works are on a large scale it is a useful plan to provide a small rest-room and nurses'-room in connection with this department. This rest-room will not only be found useful for patients after treatment in the first-aid room, but will serve for the minor breakdowns that a short period of rest will put right.

Cycle Store.—Where the workers live at a distance from the factory, a store for cycles should be provided. This may take the form of a open shed with roof projecting far enough to keep rain from falling on the cycles. A locking arrangement should be provided for each cycle, and much space may be saved by setting each alternate machine on a slope that raises handle bars above those adjoining on either side.

Garage and Petrol Store.—In many businesses a fleet of motor vans or lorries is now a necessity, and where this is the case a garage must be erected. This and the petrol store should be placed as far as possible from the other buildings, and arrangements for preventing petrol entering drains provided. See Chapter VII.

Canteens and Welfare Buildings.—These are considered in Chapter XI., but the suggestions on page 4 should be remembered in preparing the general lay-out of the scheme.

Roadways to Works.—Where possible, "in" and "out" gateways should be provided, and the roads into the works and the roadways between buildings should be paved. If no footpaths for workers are provided, the roadways should be laid to fall to centre rather than to sides, so that water is diverted away from buildings.

Where, however, much heavy traffic may pass between buildings, the provision of footpaths will be found not only convenient for workers but will prevent wheels and hubs of vehicles from coming in contact with factory walls. If tramways or metals are laid along the roads the surface of footways should not be more than 3 ins. below factory floor, and the surface of road but 4 to 5 ins. below footpath, as otherwise trouble will be found in the sudden rise from roads to shops.

CHAPTER IV.

THE CONSTRUCTION OF THE FACTORY BUILDING.

In the choice of materials for the erection of factory and industrial buildings, the following three matters call for attention :—

Durability.
Fire-resisting qualities.
Cost.

It is assumed that any structure is desired to be strong enough to serve some useful purpose for at least eighty years, and this first quality is satisfied by most methods of construction in general use if properly carried out. (Temporary buildings and sheds are often required in connection with factories, but these will be considered in Chapter VIII.).

A factory, if built with brick walls and timber-framed floors and roof, may be considered as a permanent building, but it cannot claim to be fire-resisting, and should never therefore be recommended.

It is true that insurances can be effected that will cover damage to the building, machinery, and goods, but no insurance can bring back lives that have been lost or rejuvenate seared and maimed bodies, and every employer of labour has a moral duty to safeguard his workers as far as is possible.

But apart from this, the break in the continuity of production consequent upon a fire may cripple a firm for an indefinite period, or allow some rival business to capture its markets, and in all cases the provision of adequate means of escape will be greater in a building with wood floors than in one of fire-resisting construction. Also insurance companies quote minimum premiums for a thoroughly equipped fire-resisting structure, and the sum of these facts taken together should persuade any manufacturer to build his premises as fire-resisting as possible.

The cost of construction will invariably rule out the employment of the more expensive building materials, such as stone and granite, and we are therefore reduced to two main methods of construction :—

A. The steel-framed building with brick wall filling and concrete floors.

B. The building of reinforced concrete.

Individual preference, the site of the building, and the availability of suitable materials and labour will all play their part in the settlement as to which system of construction shall be used, but if the former is decided upon all steelwork should be encased with fire-resisting materials, for, as is well known, the high temperatures generated in most big fires cause exposed steelwork to bend and twist owing both to their own and the superimposed weights upon them. Walls are pulled and pushed over, and the results of such movements is greater than the damage by fire and results in reconstruction having to be commenced at the foundations.

Whilst dealing with the general system of construction it may be of interest to return to the subject of vibration which was referred to in dealing with the building of several stories (see page 7). The architect is often asked the question: "Can you do away with all vibration in my new building?" and whilst it is improbable that a building can be erected in which vibration will be totally eliminated, the general consensus of opinion inclines to the view that structures of reinforced concrete give less cause for complaint on this head than those of steel-frame construction.

This subject has been investigated in the United States, and the results of the Aberthaw Investigation of the effects of vibration in structures was given in a paper to the American Concrete Institute in February, 1917. Questions as to vibration in different buildings had been previously sent out to engineers and manufacturers, and about 1150 replies were received.

A summary of these shows that the reinforced concrete building has in the U.S.A. been found far preferable to any other, and the paper should be read by all interested in this subject.

Walls.—If building acts and bye-laws were not administered in so stringent a manner, and if cast-iron rulings gave place to discretionary powers, the cost of erecting industrial buildings would be greatly reduced, and the building of reinforced concrete would generally be found to be much cheaper than the steel-framed and brick building.

As, however, in most districts there is no possibility of using walls of less thicknesses than 9 ins. or 14 ins., the cheapest and most general form of construction is to build the structure with reinforced concrete or steel beams and supports, and to use brick-filling in the panels left where not occupied by windows or openings. Windows

will be fully dealt with in the chapter on lighting, but it may be noted in dealing with the walls that the higher the distance from floor to floor the greater the possible height of window, and consequently, as natural light can carry further, the greater the possible width of factory.

Reinforced concrete piers will, of course, take up more space than steel stancheons, but the saving in cost will compensate for this, and often when the increased area taken by the steel encasing is added the difference is found to be almost negligible. Piers of octagonal form are to be preferred to square ones, but if the latter are used the arrises should always be taken off, giving a splay of at least $1\frac{1}{4}$ ins. across.

Floors.—In the construction of floors calculations should always be made of several arrangements, but a system of main and secondary beams will generally prove most economical.

The beams in the walls can be arranged to serve as heads of windows, whilst their upper surface will form the support of the brickwork under sills, but in these cases the face of beam should be kept back a little distance from wall face and left rough to receive a finished surface.

This arrangement expresses the construction of the whole structure and should form the basis on which the architectural character of the building is developed. See Chapter XIII.

In the choice of finishings of floors a great many materials are to hand, but it should be remembered that traffic is generally very heavy on factory floors, and the cost of maintenance should be considered in comparing the first costs of the materials proposed to be used.

The trade carried on within the building will partially settle the material to be employed, but ordinary concrete should never be used without some finish such as steel slag or granite chips. The latter is probably the cheapest satisfactory floor that can be used, but has the following disadvantages:—

Cracks occur and chips may be broken out by sudden impact.

Tools are broken or blunted by falling upon it.

Complaints of cold feet are often made by the employees.

A fine dust is worn off under heavy traffic. (This can be greatly obviated by the employment of one of the many surface finishings now on the market.)

The following table gives a comparison of the relative costs of different floor coverings expressed in percentages of the most expensive, and is based on prices current in 1914:—

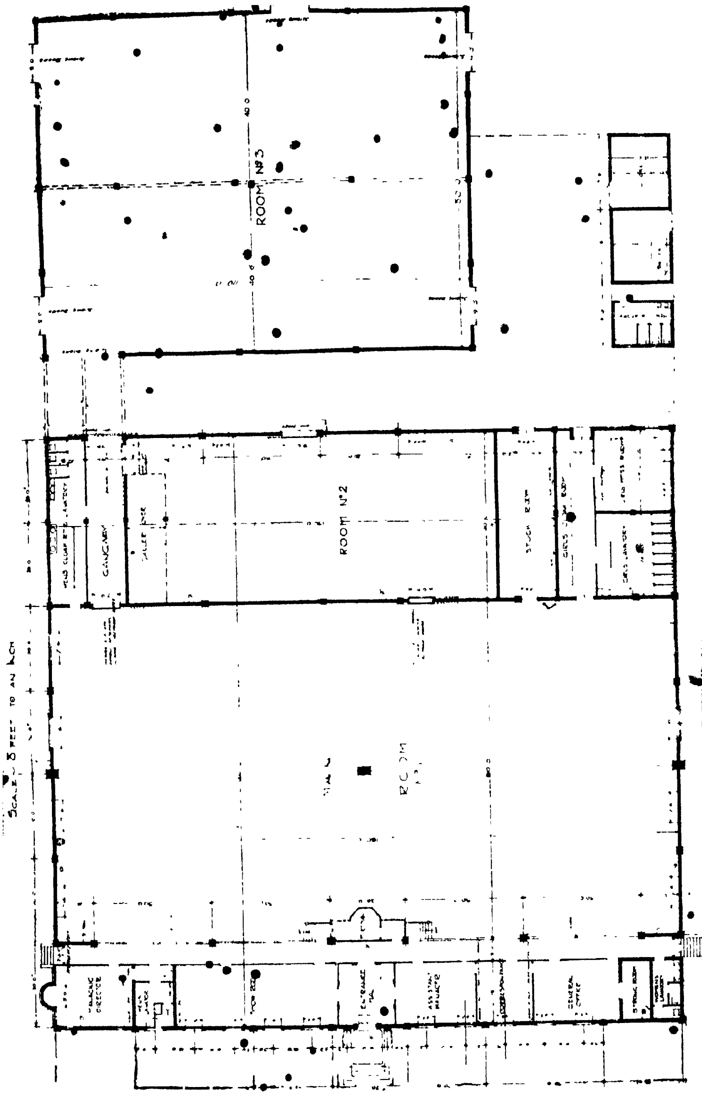


FIG. 9.—Factory with one central supporting pillar. (A. Alban Scott, Architect.)

1½ in. oak blocks	100
2 in. deal blocks creosoted	58
1½ in. maple blocks	66
1½ in. deal blocks	51
1¼ in. maple boarding	45
1¼ in. pitch-pine boarding	40
1½ in. yellow deal boarding	30
Patent jointless flooring	37
¾ in. asphalt in two layers	44
Blue brick paving	46
Quarry paving	65
Granolithic finish paving	20
Paving with cement finish	16

Where cement, stone, or cold material is used for floors, standing boards are often needed by the workers, and when that is so, care is needed in their construction to prevent the possibility of tipping up and throwing workers on machine or on to floor.

In galleried factories, where an open balustrade is used, a fillet should be fixed at nose of floor to prevent any bolts, tools, etc., that may be dropped from rolling along floor and falling on the heads of workers below.

Concrete, it should be remembered, becomes badly stained if oil is spilled upon it.

Doors.—Except to staircases and exits top-hung sliding doors are preferable to those hung at sides. Handles should be of drop flush type, and all fittings beyond general door surface avoided.

The brickwork opening to all doors used by the workers should be finished with bull-nosed angles, and in positions where much traffic occurs, or where workers will rub against them, glazed or blue Staffordshire bricks should be used.

Roofs.—Where the roof is flat its construction is of course similar to that of the floors below, except that the upper surface is laid to falls and finished with a material that will be quite waterproof.

Where the lift runs up to and gives access to the roof there is great possibility of goods being stored upon it, and this should be allowed for in any calculations made for its load.

There are several patent roof coverings now on the market which are fairly satisfactory, but for general use asphalt surpasses all other materials. It is in our climate unaffected by heat or cold, and a roof covered with it can be used for storage and for fairly heavy traffic or as a resting-place for the employees.

It also lends itself to the formation of gutters, skirtings, and any purpose where lead or zinc were formerly employed, but certain precautions must be taken where steep slopes occur. In such cases, and where used on boarding, felt and expanded metal should be first laid down, and in all cases the material should be in two layers breaking joint.

Where sloping roofs are used roof principals of steel or reinforced concrete construction are a necessity. Until a few years ago

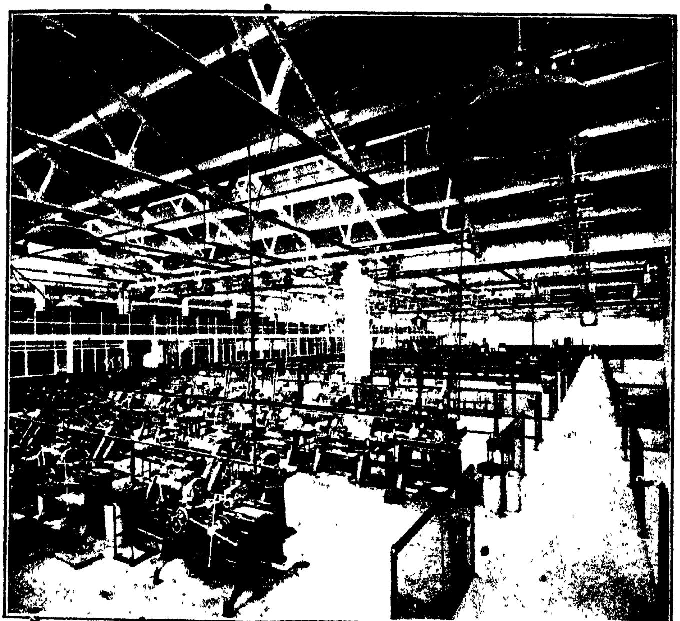


FIG. 10.—Interior of factory. (A. Alban Scott, Architect.)

steel or timber was invariably used, but improved methods on centering have now made reinforced concrete principals as cheap to form as steel ones.

In chemical works or buildings where corrosive acids would act on metal work, principals of teak will be found most suitable.

For the external covering of sloping roofs a great many new materials have been introduced during the past few years. Some are cheaper and lighter than slates, but bearing in mind that few of them have had time enough to prove their capabilities and that

dilapidations will accrue on permanent building, the wisest plan appears to be to use materials that have stood the test of time.

Staircases.—Staircases for industrial buildings may be divided into three classes :—

1. Small staircases and ladders for access from one floor to another used mostly by foremen and administrative staff.
2. The main staircases for access to the various floors.
3. Staircases solely for escape in case of fire.

1. The first class, notwithstanding their normal use, should always be constructed of teak or hardwood, have fire-resisting soffits, and be as like to ordinary staircases as is possible in the space available. Accidents are always more likely to occur on steep, than on shallow stairs, and in times of panic or fire it is often found that a rush is made for the nearest outlet, even when proper fire exits are provided

2. The main stairs of the building should always be of stone or concrete encased with brick walls, and the type of stairs shown in Fig. 8 is to be preferred to any other.

Windows should be arranged to give direct light to both flights, and if this is impossible a glazed sash should be fixed in the spandrel wall.

In order to diminish the risk of accidents, the first step downwards in each flight should be kept back some few inches, as shown in Fig. 8, and handrails should be fixed on both sides of stairs, carried round landings, and chased into newel walls.

The treads should be grooved or otherwise treated to prevent slipping, and no flight should consist of more than fifteen risers.

Under the London County Council's rules for factory stairs, a minimum of 10 ins. width and a maximum of 7½ ins. rise is permitted, but experience of climbing many flights proves that it is easier to climb a distance with 6½ ins. rise than one of 7½ ins., and as no employer wishes his workers to be out of breath by the time they get to their workroom, the smaller riser should, if possible, be used.

The traffic up and down staircases will soon render brick walls very unsightly, and if the spirit of cleanliness is to be fostered in the works the enclosing and newel walls should be faced with glazed bricks. Where this would be too expensive, a dado only of glazed bricks may be used and the walls above painted. All ceilings and soffits should also be finished white, either by paint or distemper.

The staircases necessary for escape in case of fire may be either enclosed as the main staircases or may be constructed as external iron stairs. If the latter, the treads should be of non-slip material, and all windows of factory in close proximity to such stairs should be

glazed with fire-resisting glazing. Handrails should be fixed on either side and a balustrade of close mesh provided.

The treads should have a minimum width of 10 ins., the risers a maximum rise of $7\frac{1}{2}$ ins., and no flight should exceed fifteen steps.

Where enclosed escape stairs are used, they should be similar to

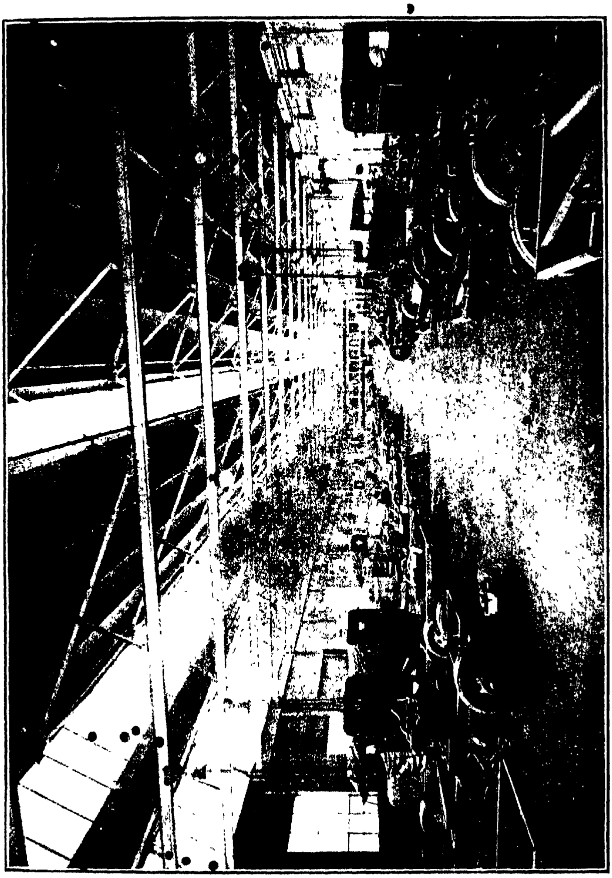


FIG. 11.—Interior of engineering works. (A. Alban Scott, Architect.)

the main stairs already described, and the provision of this type of staircase will generally reduce to a minimum the accidents that invariably occur in times of panic.

Where ample staircases are provided in a factory emergency means of escape are not needed, and although every staircase takes

up room the provision of an extra one will often save much time in the works.

In deciding the position for the staircases in the factory, endeavour should be made to place them at opposite ends or corners, so that the workers have at least one alternative means of escape in case of fire. Where timekeeper's office is placed near stairs care should be taken to so arrange it that the workers who have registered in order to reach staircase do not have to pass those coming in; also the entrance to locker-room, lavatories, etc., should be adjacent to stairs.

The employee should enter the workroom ready to commence work, and after he leaves it and takes his hat and coat from the locker there should be no necessity for him to pass through any manufacturing portion of the factory.

The doors from staircase to street or open air should open outwards, and a space equal to full width of stairs should be provided between bottom step and door when closed.

All other doors to staircases should be of fire-resisting materials hung to swing both ways clear of steps, and upper panels should be glazed with fire-resisting glass at such height that both boys and girls as well as adults working in building can see through them.

Lifts.—In order to reduce as far as possible all risk of the spread of fire, lifts should be encased with brick walls at least 9 ins. thick, and openings fitted with doors of fire-resisting material made to close automatically in case of fire, and where any of the walls of enclosure are external and abut upon an open space, one or two small windows should be formed at intervals to give light in cases of breakdown.

Pipe Well and Ducts.—Wherever a great number of pipes are needed to serve different floors of a building, a pipe well should be built to contain them. Access to it should be provided at bottom floor level and at roof, and iron steps or ladder with handrail should be fixed from bottom to top.

From it the pipes for each floor will run into ducts, which can generally be formed within the depth of the secondary beams, but in no case should they be below the mains beams.

The floor of these ducts should be laid to a slight fall to outlet, and their covering should line with floor, and be made so that it can be readily removed and every part of duct laid open to inspection when necessary.

Arrangements for Shafting, Wires, etc.—One objection often raised to buildings constructed of reinforced concrete is that shafting cannot be fixed without cutting into piers and beams, but if proper measures are taken all such cutting can be avoided.

Where no forethought has been shown the objection is valid, but if proper measures are taken during construction no interference with the structure should be needful.

Where the position of machines is definitely fixed bolts or shaft hanger inserts can be built in during construction, and arrangements should always be made to allow for shafting to be fixed on all four sides of free standing piers.

In many factories provision has been made for carrying brackets, pipes, etc., by forming grooves about 1 in. wide and ½ in. deep along both sides of all beams and vertically up each pier, and where the

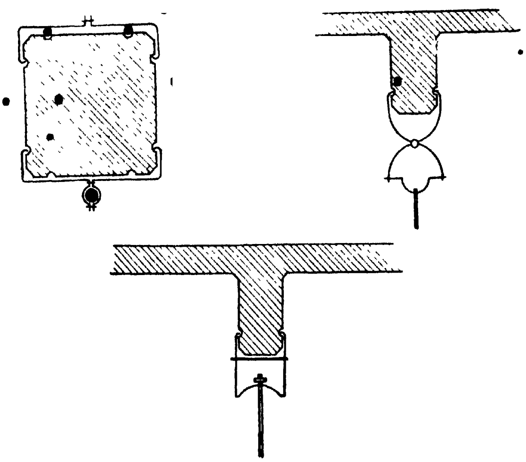


FIG. 12.*

work has been carried out in a satisfactory manner, such grooves will carry any reasonable weight that may be attached to them (see Fig. 12).

Where it is necessary that pipes and wires must pass through beams and floor slabs, the holes should if possible be formed during the construction of the building, and in any case an insulation should be formed between the wires and the concrete work.

The damage to a building owing to leakage of electricity may easily become serious, and a test of the whole system should therefore be made every three or four months.

* Fig. 12 is reproduced from "Reinforced Concrete in Practice," by permission of the author, A. Alban Scott.

CHAPTER V.

LIGHTING.

If the average man in the street was asked what was the most outstanding difference between the factory of the past and that of to-day, he would probably reply that the old factories possessed large wall surfaces and few windows, whilst the new factories were nearly all windows. The small lighting surface of the former was in many cases due to the large amounts of brickwork necessary to carry the floors and roofs, but the possibility of concentrating all weights on reinforced concrete piers or steel stancheons built into walls allows any building to have the maximum allowance of natural light.

The provision of abundant lighting to the factory will be beneficial both to the employer and to the employee, to the former in that material will not be lost, mislaid, and wasted so much as in dimly-lit buildings, and to the latter because his health will be improved and the spirit of cleanliness fostered.

Accidents will also be far less frequent in well-lighted than in gloomy buildings, as is proved by statistics published by various bodies. From these it is seen that the smallest number of fatal accidents occur in midsummer months when days are longest, and the greatest number during the winter months, also that the number of accidents for the intervening months corresponds fairly regularly with the length of the natural daylight.

The whole subject of factory lighting has been lately investigated by the Departmental Committee appointed by the Ministry of Munitions to report on lighting in factories and workshops, and the following extract from their report is of interest. In it the essentials of good lighting are summarized as—

A. Adequacy.

B. A reasonable degree of constancy and uniformity of illumination over the necessary area of work

C. The placing or shading of lamps so that light from them does not fall directly on the eyes of an operator when engaged on his work or when looking horizontally across the workroom.

D. The placing of lights so as to avoid the casting of extraneous shadows on the work.

The report goes on: "Natural lighting is to be preferred to artificial lighting on grounds of health as well as economy. Where it can be arranged roof lighting is generally to be preferred to lateral lighting. In a good system of roof lighting the illumination is very uniform. In modern factories where lateral lighting is employed a large part of the walls are devoted to windows, but it is evident that there is a limit to the width of the room beyond which the illumination falls below what is adequate; what this width is will depend partly on the nature of the work to be done in the shop and partly on the extent to which the light is impeded by outside obstacles, such as neighbouring buildings, or inside obstacles, such as machinery.

"The effect of light-coloured walls and white ceilings on the general brightness of the room and in affording an effective background to dark objects should not be overlooked. In some cases the natural light may be improved by deflecting vertical light into the room by means of reflectors or prismatic glass, or by whitening the surface of an external wall which obstructs the light. The position of permanent working points should be so adjusted in relation to the windows and to internal obstructions of whatever kind as to secure so far as practicable adequate daylight for each.

"The necessity for the regular cleaning of windows on the inner and outer surface cannot be too much insisted upon. Not only do dirty windows prevent a large proportion of daylight from entering the shop, but the daylight period of work is considerably shortened and needless expenditure on artificial lighting incurred in consequence."

It must be admitted that in some modern buildings where the windows run from floor to ceiling, difficulty is experienced in regulating the temperature of the building and in preventing the formation of cold sheets of air that set up draughts, but such troubles can generally be eliminated by a properly designed system of heating with hot-water or steam pipes around the window openings.

It is, however, doubtful if the light obtained below about 2 feet from the floor is compensated by the cost of its provision, but in most works endeavour should be made to make at least half the surface of external walls as window and the top of all windows should be close to the ceiling.

Where this is done a rough guide for the width of room that can be naturally lighted is:—

For rooms lighted on one side only: Multiply distance from floor to top of window by 1·75.

For rooms lighted both sides: Multiply distance from floor to top of window by 4·0 (see Fig. 13).

In applying these rules it is assumed that glass begins at about 3 ft. from floor, and that the width of piers between windows does not exceed one-seventh of the width of the sashes, also that walls and ceiling are finished in light and white colours and kept clean, and that no obstruction by adjoining building is present.

In the latter case prismatic glass or reflectors will generally pay for their cost, and in every case a glass that will diffuse light is better than a plain sheet of transparent glazing.

Turning to the consideration of the material for the construction of windows, the use of steel sashes is to be preferred in all cases. The total area taken by the wood itself in wooden frames and sashes bears a considerable proportion to the whole brickwork opening, and beyond this wood sashes are not fire-resisting, whilst frames of cast

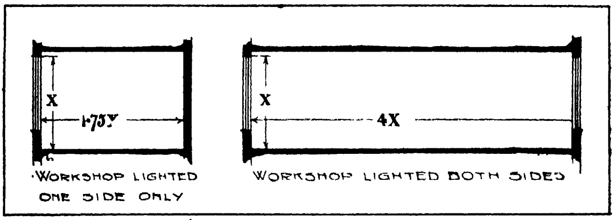


FIG. 13.

iron cannot be adapted to the requirements of ventilation, opening, etc., as can those of steel.

Steel sashes, moreover, are now nearly if not quite as cheap as other forms of windows, are not so easily broken, and allow for opening arrangements to be made in the width of the bars.

In all rooms occupied by workers provision should be made for opening any part of the window, and the divisions should be in an equal number of multiples and hung so that the outside of the windows can be cleaned from the inside of the building; and if this is not done, provision should be made for suspending cradles from the roof level in all high structures.

In all cases the maintenance of windows and their cleaning is an expensive item, and although the cost of windows in the first case may be but little more than that of an equal area of the surrounding walls, a wall once built incurs but periodic costs for inside colouring or painting, whilst windows need constant cleaning and renewals of broken panes.

To save time and expense endeavour should be made to design all windows of same size or multiple of some size, and this should also apply to the panes. A stock of sheets of glass cut to the standard pane size should always be kept in the works so that broken glass may be at once replaced.

In order to reduce the cost of windows suggestions have been made to use glazing bars similar to those used for roof glazing, but the disadvantage of not being able to open such windows and the difficulty of cleaning them will in many cases outweigh the saving in cost.

The choice of glazing material is more difficult than appears at first sight, for if a window receives direct sunlight the flood of intense light through clear glass is apt to cause more eye strain to a worker near it than would be occasioned by working in a dimly-lit room.

(This point will be easily appreciated by any draughtsman who has worked on white paper in front of a window receiving direct sunlight.)

Blinds will, of course, obviate this, but they are expensive, require frequent renewal, and greatly reduce the lighting of the centre of the room, and whitening the glass or glazing with ground glass also have the latter effect.

As is pointed out in the report quoted previously, a reasonable degree of constancy and uniformity of illumination is the ideal to be striven for, and this can be most easily and economically obtained by the use of $\frac{1}{4}$ in. ribbed plate cut so that the ribs run horizontally across the panes.

The artificial lighting of factories must be suited to the work to be carried out in each department, but wherever possible indirect lighting should be used. Experience has proved that headaches and other effects of eye strain are diminished by its use and a diffused light with no shadows is obtained.

Where much shafting and belting occur, where small and fine work is being executed, and where many machines are installed, point lighting is necessary, but even in these cases the normal lighting of the room by indirect methods will generally be found preferable.

Whether electricity or gas are used may depend on individual preference or other causes, but if the latter is installed incandescent mantles should be used, and in all cases of indirect lighting it should be remembered that several smaller lamps, distributed in each bay, will give better results than one large one even if of slightly greater candle-power than the sum of the lesser points.

The best type of bowl for indirect lighting for factory work is made of enamelled iron, and it should be some one's duty to remove dust, and clean the internal reflecting surface at least once a week.

Where general lighting is provided, point lights need only to be strong enough to enable the employee to carry out his work, for eye fatigue may be caused as much by excessive glare as by lack of light. Ten or at most sixteen candle-power lamps arranged with shades or reflectors to throw light exactly where required are all that is necessary in most works.

A great saving may also be effected where the supply is by alternating current if a transformer is installed to break down the voltage to 50 and by using lamps in series.

It should also be remembered that the filament of a 50-volt lamp is much stronger than that of high voltage lamps, and that therefore the use of such a system will greatly reduce lamp costs in the course of a year.

The finish of the rooms of the factory will play an appreciable part in the lighting effects, and will also tend to raise or deaden the spirits of the workers, and for this reason it will be found beneficial to carry out simple schemes of colour throughout the building.

Dark colours absorb the natural light whilst light ones reflect it, and therefore for the walls light shades of yellow, green, or grey should be used, and the material be capable of being washed down at frequent intervals.

The ceilings should be white, and where reflected lighting is used the extra cost of enamelling will be repaid by the greater reflecting power obtained from its surface.

CHAPTER VI.

VENTILATION AND HEATING.

Of the two, the former is by far the more important, for although many factories and shops can well dispense with the latter, there are very few trades carried on where some system of ventilation is not a necessity for the workers.

Ventilation has for its object the removal of the vitiated air and its replacement by fresh air, which latter is defined by the Health of Munition Workers Committee as air which is: (A) Pure and clean for the workers to breathe, and (B) an atmosphere which is stimulating and refreshing. Air which is entirely pure from the chemical point of view may afford an atmosphere of a most depressing character which is highly detrimental to physical efficiency. It is not enough to aim only at clean air, as has been often customary in the past, or only at a stimulating atmosphere. In any consideration of ventilation both objects must be constantly in mind.

However pure the atmosphere of a factory may be before work is commenced, no sooner have the workers entered and machines begun to run than various impurities begin to infect the air, the chief of which are:—

1. Carbonic acid gas.

2. Various ill-defined volatile substances arising from human beings, especially where personal cleanliness is lacking and perspiration is profuse.

3. Bacteria.

4. Dust, fumes, and impurities given off from processes of manufacture. Carbonic acid is given off in the breath of human beings, and by fires, etc., and its increase is accompanied by a diminution of the oxygen in the air. Its gradual formation is not at first noticeable to those working in the room, but is at once apparent to anyone coming in from the open air.

It has been stated that 500 persons will in one hour produce carbonic acid containing about 25 lbs. of pure carbon and 4 gallons

of water, and if this atmosphere condensed on a wall was collected a few drops of it would poison a rabbit.

It "must not however be assumed that the presence of carbonic acid in the atmosphere is the only evil; for the bacteria arising from human beings may form a more definite and directly harmful source of impurity. There is no doubt that the common catarrhal conditions (colds, sore throats, 'influenza') are for the most part spread from an infected individual to his neighbours by organisms that are carried in the expired air with droplets of moisture, especially during coughing and sneezing, though also during ordinary breathing and speaking. These diseases are often regarded as trivial in character; it appears likely, however, that if any correct estimate of lost time and diminished output owing to 'colds' could be obtained, these would prove to be the most important infectious source of industrial inefficiency. Of diseases more serious as regards life as well as health, tuberculosis of the lung is undoubtedly often disseminated in a like manner.

"It might be argued that if greater cubic air space was given to the workers, most of these troubles would be eliminated, but such requirement would in many cases be impossible. If a factory is to be efficient, space must not be wasted, and apart from this, in many buildings where large machines with few workers are employed, masses of stagnant air are found which exercise a deadening influence on the inmates."

The report above mentioned characterizes the desirable air as being:—

Cool rather than hot.

Dry rather than damp.

Diverse in its temperature in different parts, and at different times, rather than uniform and monotonous; and (which is intimately connected with this diversity),

Moving rather than still.

Each trade and factory will raise its own problems, and will be affected by the height of room, its different uses, and the number of persons employed, but in no case should the air be changed less than four times per hour, and in some buildings it may be necessary to provide for changes every four minutes.

This can be arranged by means of fans, but in all cases windows should be formed to open direct to the external air.

A simple system of ventilation for single story shops can be installed by pumping fresh air into the building and allowing the vitiated air to escape by means of louvred ventilators at the ridges and under eaves.

Beyond the general ventilating system, provision should be made for removing as far as possible all dust fumes, etc., at their source. In many factories this can be effected by fixing a hood over each machine and connecting it by means of a pipe to a duct. An exhaust fan fixed at end of this duct will draw away all dust as it is produced, and this dust should not be disseminated into the atmosphere but should be deposited into a properly constructed receptacle.

Even when this is done, and a perfect system of ventilation is installed, much dust, fluff, and particles of impurity from machines, floor, and materials will be present, and where work is delicate, and must be kept clean, a vacuum system should be provided, and one or more suction points or plugs fixed in each room.

The question of the ventilation of a building is always closely allied to the heating, and in many cases the two are incorporated into one scheme, as in the "plenum" system, where the air is pumped into the building after being warmed in winter, and cooled in summer. In this system the air is drawn into the building through screens (down which water is caused to run) which remove all dust, and the warmed or cooled air is driven through ducts to the inlets in each room; and there is no doubt that it is by far the most scientific system at present in general use.

Whilst this is so, the Committee above referred to consider that it should only be used for pumping cool air in summer time, as in practice, warmed air so supplied is relaxing and of depressing character.

A perfect system of filtering air has, however, still to be produced, as the usual practice of relying upon a spray of water tends to increase the humidity of the atmosphere.

Other disadvantages are :—

1. The necessity of ducts and trunks which often take up valuable space and interfere with shafting.

2. The need in large works of two or more plants or an excessive number of fans.

3. The continual and heavy cost of upkeep.

Where this system is installed care must be taken in the placing of the outlets for foul air; for it may happen, where these are connected with ducts leading to the extract fans, that direct currents are set up from inlet to outlet and the spaces between left as masses of stagnant air.

There are three other systems of heating industrial buildings in general use, viz. :—

1. Radiant heat.
2. Steam or high-pressure hot water.
3. Low-pressure hot water.

Radiant Heating.—Radiant heat is doubtless the ideal form of heating, and in small workshops can be easily effected by stoves or fires, but the trouble and expense of fuel supply, cleaning, and risk of fire occasioned by its use makes such method of heating quite impossible and undesirable in works of any magnitude.

Steam Heating.—Where steam engines and boilers are part of the factory organization, and where sufficient exhaust steam is to hand, this system will be found both cheap and effective.

It however has certain disadvantages :—

1. The grease (in suspension in the steam) from the engines must be removed.

2. Any air in the pipes causes distinctly unpleasant noises in the works.

3. Trouble is apt to arise in controlling the temperature.

4. Allowance must be made for drawing off condensed water from the pipes, and this can only be done by giving them a slight fall, which in large works often means that pipes or ducts must in places drop lower than the main beams.

5. Being exhaust steam it often lacks enough energy to cause it to travel through pipes. This last difficulty can be overcome by working the heating system on the "vacuum" principle.

6. A properly skilled engineer must be placed in charge of the system.

High-pressure Hot Water.—This system is not to be recommended for heating buildings where workers are constantly employed, but is most useful for drying and stoving rooms.

The pipes used are small, a comparatively small boiler is required, and the building in which it is installed can be heated very rapidly, but these advantages are more than outweighed by the following disadvantages:—

1. Danger of explosion is greater than in low-pressure systems.

2. Pipes must be filled at intervals and also pumped to get rid of air bubbles.

3. If building is left unheated in cold weather there is more risk of freezing than with other systems. (This can be prevented by the use of non-freezing solutions in the pipes.)

4. Owing to the high temperature of the pipes when system is working the dust in the atmosphere near them becomes charred.

5. A skilled engineer must be placed in charge of the system.

Low-pressure Hot Water.—The working in this system may be effected by two methods:—

A. Where circulation relies on natural means.

B. Where circulation is helped or accelerated by means of pumps.

Except in very small buildings the second system will be found the more convenient, as by its use smaller pipes are required, the flow is more rapid, and in all cases the presence of dips owing to beams etc., raises no special difficulties that lead to breakdown. Moreover, a highly skilled engineer is not needed to look after it.

Where therefore the heating of the building is to be carried out by hot water, a low-pressure system will generally be found most convenient.

Generally.—In placing the radiators a number of smaller ones will give better and more equitable heating than one large one, and where large windows occur a radiator should be placed in front of each of them.

The pipes for supply should run up pipe well and connect at each floor level to ducts from which the connections should be made to each radiator.

In offices, showrooms, and all departments where walls are finished a light colour, a shelf should be formed above each radiator to prevent stains and dirty smudges being formed on the wall above.

Wherever lantern and overhead lights occur hot-water pipes should be run around their base in order to prevent the formation of cold masses of air which set up draughts that greatly inconvenience those working below them.

The boiler-house should be placed as central to the whole works as is possible, and if arrangements are made for future extensions its position should be relative to the completed scheme, and it should be constructed large enough to receive the extra or extended boilers that will finally be required. Its floors should be below the general factory level and a gulley formed to take off water when system is emptied. Ample bunker space for fuel should be provided, and a cupboard or recess for the engineer to keep necessary tools and spare parts is a desideratum that is often omitted.

The chimney, which should be fitted with sweeping door, damper, or air door, must in large installations be lined with fire-brick for part of its height, and a ventilated space formed between this lining and the brick enclosure. Circular or square flues give better results than rectangular ones, and the ventilation engineer should always be

consulted as to the cross area of flue and the height of chimney that is required.

Opinions greatly differ as to the limits of temperature that should be maintained in factory and industrial buildings. The work carried on in the structure does in certain cases control both the temperature and the humidity of the atmosphere required, and in such cases the heating engineer is rigidly controlled by maximum and minimum fixed limits. But apart from such cases the temperature of workrooms should be such that the worker is comfortably warm whilst engaged upon his duties, and the following have been found by experience to be satisfactory:—

For heavy manual labour . .	44 to 48 F.
For heavy labour at machines .	46 to 50 F.
For lighter labour at machines . .	50 to 54 F.
For very light labour at machines	58 to 66 F.
For sedentary work	58 to 64 F.

Where a garage forms part of the scheme a branch should be carried from boiler in order that water in car radiators may not be frozen during wintry nights and week-ends.

In such a case, and wherever pipes must run from one building to another, they should be well wrapped round with some non-conducting material, or, better still, packed in such material in concrete ducts formed underground, and during the winter months a small fire should be kept under boiler so that a limited circulation is maintained.

CHAPTER VII.

THE SANITATION OF THE FACTORY.

The provision of improved sanitation in the factory is a phase of welfare work that has been too long neglected.

It must be admitted that Public Health Acts and Factory Inspectors have made the state of things which existed some years back quite impossible to-day, but even now legislation can only insist on the provision of what conveniences are necessary for common decency. It is no good making the factory cheerful and bright if lavatories and W.C.'s are dull, dirty, and sloppy, and the provision of white walls and white glazed fittings will, if installed, foster the spirit of cleanliness that is so much to be desired.

For the purpose of this chapter sanitary work is divided into:—

1. General considerations.
2. Intercepting lobbies.
3. Lavatories.
4. W.C.'s
5. Urinals.
6. Baths.
7. Drying rooms.
8. Locker rooms.

General Considerations.—The floors of all the above departments should be of impervious material laid to a slight fall to glazed channels or gulleys, so that any water that may be spilled on them will drain away, and so that no possibility exists of the formation of pools of water on the floor.

A stand-pipe with length of hose should be provided in order that the floors may be washed down and squeegeed at frequent intervals. The walls should be lined with glazed bricks and the junction of floor with walls made by a slight curve, also all corners should be rounded.

Thin glazed materials and tiles have been recommended for wall linings, but as these buildings are always subjected to comparatively heavy or rough usage, glazed bricks are much preferable.

Where the provision of glazed bricks is thought to be too extravagant, a dado of them with upper part of walls painted may be substituted, but the cost of re-painting at intervals should be taken into account in considering the initial outlay.

The divisions between W.C.'s should be finished in white glazed material, and if they are raised a few inches from the floor, greater cleanliness is obtained by the fact that they can be washed down more easily.

Hot and cold supplies should be provided in the lavatories on every floor of the building to enable window or other cleaners to fill a bucket with water without having to rest it in a lavatory basin, and if the mouth of the bib-cock is threaded to receive the hose-pipe, the stand-pipe before-mentioned need not be provided.

Lobbies.—Intercepting lobbies should in all cases be placed between the manufacturing portion of the works and the sanitary conveniences, except where the latter form distinct buildings.

These lobbies should, if possible, be cross ventilated, but in any case large windows, with portions permanently opened, should be provided.

Lavatories.—It is often stated that workers will not use lavatories where they are provided, and although this may occasionally happen, experience has proved that when proper facilities are given they are used by an ever-increasing number of the workers, and the evidence of a recent Trades Unionist is interesting: "Material improvements in the arrangements for washing are desirable. It would be a great help if a worker could have the opportunity for really washing up and putting himself in a condition to go out with his family without having to return home first. Anything in the nature of evening recreation is rendered almost impossible if a worker has to travel all the way home, perhaps right through the city, and get cleaned up before returning to the city with his family."

Two types of lavatories are now in general use.—

A. Separate basins.

B. Washing troughs.

In both cases the material should be white glazed, the fittings of strong construction, capable of hard usage, and taps, wastes, etc., as simple as possible.

Where basins are used the chains and plugs often get broken and lost, and workers leave basins full of dirty water; and to obviate this trouble, the washing trough is becoming more and more general.

It is generally placed so that workers can stand on either side of

it, and consists of an open trough with a waste pipe discharging on to a channel in floor.

The water is delivered through a pipe pierced at intervals, and washing is carried out under the spray delivered, but for occasional use a spray tap is also provided, and this should be fixed at such a height that the head and neck can be washed under it.

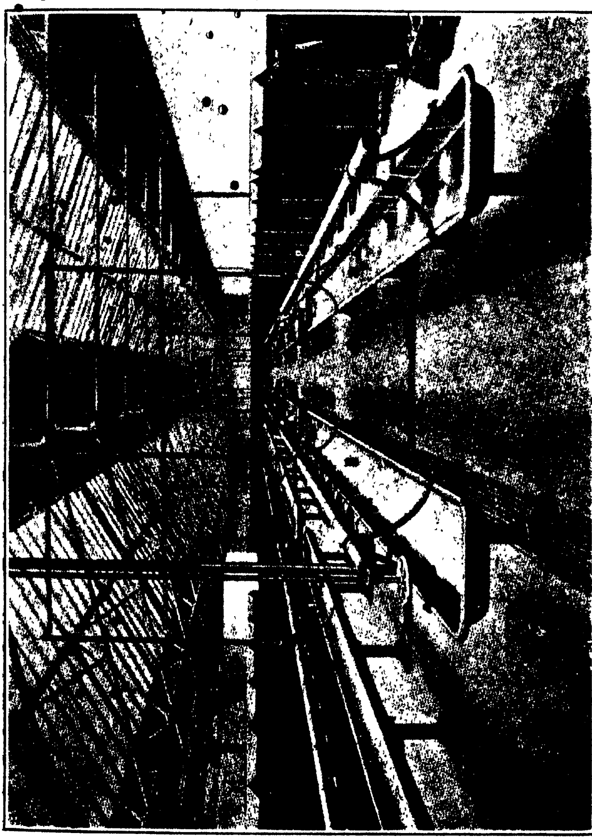


FIG. 14.—Lavatory in engineering works, Trafford Park, Manchester.

Where this trough system is used the attendant regulates the flow and temperature of the water, and turns it on as the workers come from the factory, also by its use facilities for washing can be given in a smaller space than would be required with single basins.

Where soap is supplied, the best form is powder or jelly, and a proper box for it should be provided.

The provision of a separate towel for each worker causes a great deal of washing, but is the most hygenic system, and in large works it will be found most economical to provide a small laundry. A department equipped with washing machine, hydro, ironing machine, and drying cupboard will easily deal with thousands of towels per day, and will cost but comparatively little for upkeep.

W.C.'s.—The latrine trough should never be installed, and wherever possible the bracket form of wash-down W.C. should be used so that no dirty corners that cannot be easily washed down are formed.

The provision of W.C. seats which rise automatically and discharge water from cistern have been widely recommended; but as they easily get out of order, and simple strong fittings are the greatest desideratum, a large automatic cistern for the whole range, or chain pulls should be used. Hardwood lift-up seats should always be used.

Efficient ventilation is essential, and should be provided for by forming a ventilating duct connected with each floor of sanitary block and with fan at roof level, as if this is not done, there is a possibility that the main factory exhaust may be continually drawing air from the conveniences into the manufacturing portion of the factory.

Urinals are always a difficult problem to deal with, unless, as in public conveniences, an attendant is permanently in charge of them; and although in large factory lavatories an attendant is provided, his time is chiefly taken up in booking time in and out, and in controlling the locker room, etc.

Whatever type may be chosen periodic cleaning is necessary, but to eliminate labour as far as possible, and to foster cleanliness, white glazed fireclay stall patterns with open channel should be used, and the floor or step on which they stand should slightly slope towards the channel. The back should be in one piece with the channel, and the junction between stalls should be on the front, so that the only joints that come in contact with water are those of the channel. Automatic cisterns with gun-metal spreader jets for washing the whole surface should always be used.

Drinking Fountains.—Facilities for obtaining a drink of water should be arranged for in every workshop, and spring valve taps over basins should be fixed at regular intervals down the shops. The use of common drinking-cups carries the risk of infection, and to eliminate this, a jet arranged so that workers' mouth cannot touch

outlet is common in American factories. If this type of fitting is installed, provision should also be made for filling a jug or glass from a tap fixed above the basin.

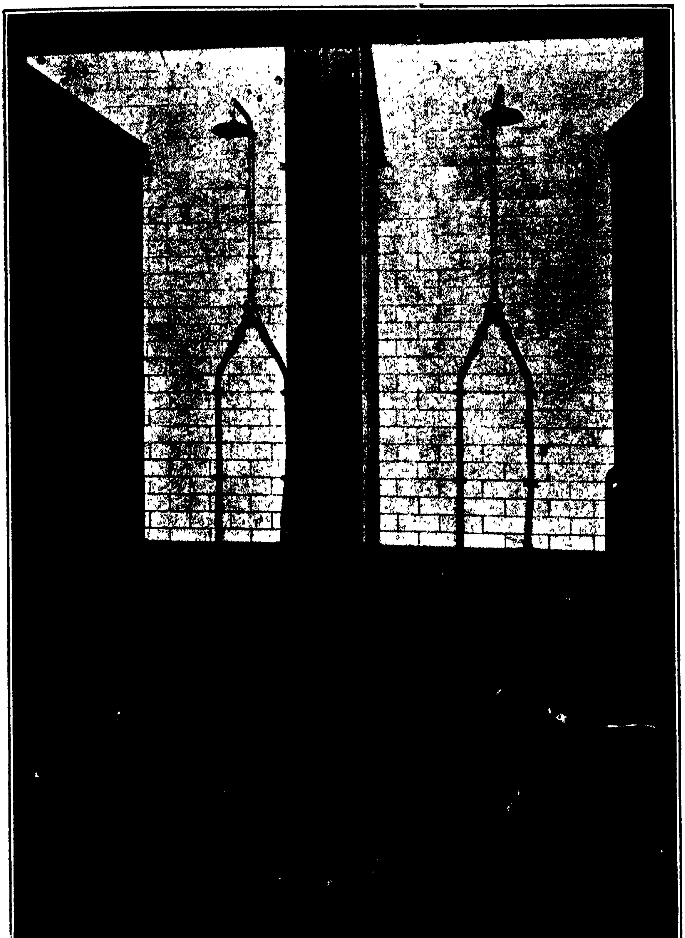


FIG. 15.—Girls' bath at Port Sunlight. Interior view.

Baths.—The provision of baths is not a necessity in the majority of factories, but notwithstanding this fact, the tendency among large American firms is to provide them, and to give every worker the

opportunity of using them (during the firm's time) at least once week.

It should be remembered, that where work is carried on under

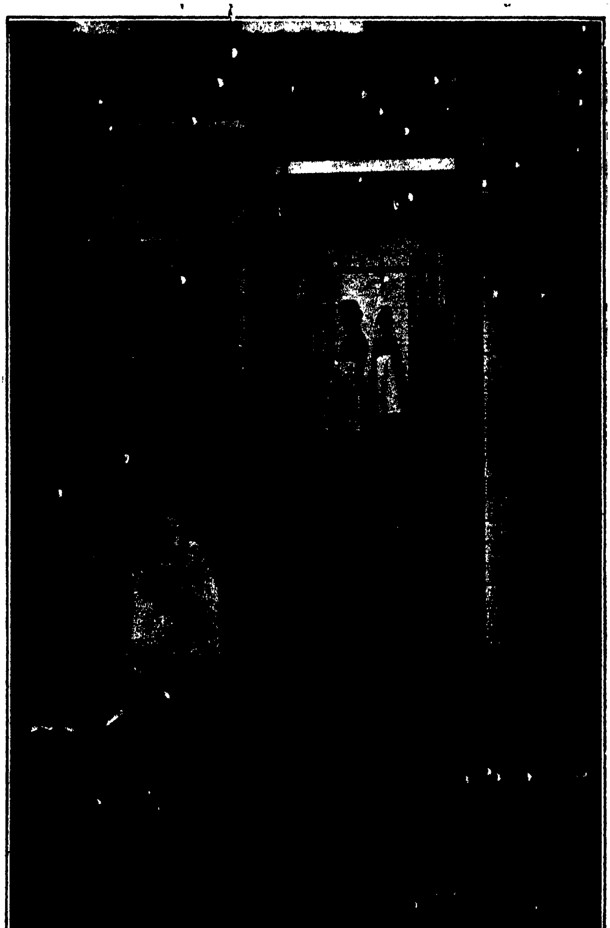


FIG. 16.—Girls' bath at Port Sunlight. Exterior view.

conditions necessitating intense heat, a bath before leaving the works will often ward off muscular rheumatism, and thus prevent absence and broken time in the factory.

Some English and many American firms provide large swimming baths for their workers, but this will be more fully dealt with in the chapter on welfare work.

Where, however, the provision of baths is vital, and where many are to be taken at the same time, the most economical and effective form is the "shower" type, and it is stated that the effect on the skin of the falling water is more stimulating than a dip or dive in a large bath. Where used by women, the position of the spray must

FIG. 17.—Girls' swimming bath, Messrs. Cadbury's works, Bournville.

be modified in order that their hair may be kept dry, and this is most easily done by fixing the spray as a ring at shoulder level or by attaching it to the end of a flexible tube.

A reasonable number of bath cubicles should be provided, but a large, heated dressing-room where workers may partially dress and undress should be placed near cubicles, for by its provision the number of cubicles will be reduced, and much time will be saved to the workers. The cubicles should be provided with doors or curtains to

secure privacy, and an open-slatted seat and clothes pegs should be fixed on back wall. A width of 3 ft. and depth of 4 ft. to 4 ft. 6 ins. is sufficient, and the divisions between cubicles should be 6 ft. 3 ins. from floor to top, the bottom being raised 3 ins. from floor to allow for cleaning. An attendant should always be placed in charge of the baths, and the temperature and supply of water should be under his control.

Drying-rooms.—In many trades where baths are a necessity, the conditions of employment require that provision should be made for drying of clothes and overalls. To place damp clothes in lockers with hot-water pipes beneath them may, but in many cases will not, be effective, and where much clothing has to be dealt with a drying-room should be built. If this cannot be arranged for, lines should be fixed over the dressing-room above referred to, and a system of pulleys for raising and lowering installed; and if the building is kept at a temperature of about 70° F. and fans fixed to keep the air in motion, the clothes should be quite dry and well aired by the time that they are again required.

Locker Rooms.—A separate locker should be provided for each worker, and on it his name or works number should be placed.

Lockers should be placed so that they are under the control of the lavatory attendant, and ample space between rows provided, so that workers can put on their coats when doors are all opened.

If the lockers are not controlled by an attendant there will generally be complaints of pilfering, and the plan of placing the lockers against walls and radiating from the attendant's office (similar to the stacks in free libraries) is a good one.

The best type of locker is of sheet iron, raised a few inches from floor and pierced at base and top with holes for ventilation. It should be fitted with hooks for clothes and a shelf provided, on which the worker may leave any property that he may not need in the works.

Drains.—In many districts the local authorities will insist on the sewage drains being kept quite distinct from those for rain water. Even where this is not the case, it is often advantageous (especially in country districts) to keep them distinct and to run the rain water to a collecting tank for future use in the building.

Whether salt-glazed earthenware or iron pipes shall be used will sometimes depend on individual preference, but in all cases iron drains should be used where under buildings.

Iron drains are more expensive than stoneware, but their advantages in strength more than compensate for their extra cost; but

when they are used their internal faces should be treated with Dr. Angus Smith's solution, or some other means taken for preventing them from rust and corrosive decay.

All junctions and bends should be provided with cast-iron inspection eyes and properly built manholes formed at each change of direction. Wherever hot water is allowed to pass into a drain, expansion joints should be formed.

Where a garage is part of the factory buildings a petrol intercepting chamber should be built between the garage and the main drain. The form insisted upon by the L.C.C., which consists of three chambers with inlet near top and outlet at bottom in all cases and with removable cover over each, will not only save petrol but will prevent trouble with the sanitary authorities.

Similar intercepting chambers should also be formed in the drains from buildings from which oils and waste products may escape into sewers.

Where a factory is built in the country and no sewage system exists, the provision of a septic tank and system is preferable to cesspools, providing always that it is possible to run the discharge over the adjoining land.

CHAPTER VIII.

TEMPORARY BUILDINGS AND MOVABLE FITTINGS.

THE past few years have, owing to the war, witnessed the erection of temporary buildings on a quite unprecedented scale, and although, as earlier stated, the employer is well advised to build permanent fire-resisting structures, it may sometimes be needful and expedient to erect sheds or buildings that will only be required for a short time. For example, where only a portion of a complete scheme is now erected, it may happen that some adjunct is required which will have to be cleared away when extensions are necessary, and in such cases a lighter form of construction is sometimes justified.

Whilst this is so, the possibility of building some of the extended and future bays, and for a time adapting them for present uses should always be considered, for matters such as drainage must be provided for, and it cannot be too often reiterated that everything should be approached with a view to the future.

Where, however, temporary buildings must be erected, the cheapest form of construction is by means of wood framing, covered with weather boarding or corrugated sheets for the sides, and with corrugated sheeting or felt for the roofs. Weather boarding is cheaper than iron sheeting but is not so lasting, and where it is probable that a temporary building will have to be pulled down and re-erected after a year or two, the use of the latter is more economical and preferable. Foundations of brick or concrete should be provided, but where floor is raised some distance from the ground, brick piers will be found cheaper and easier to form than concrete ones.

As in the construction of the permanent building, the setting out of these structures should be as far as possible standardized, and if it can be arranged, small spans should be adopted for joists and roof principals. The latter should also be of low pitch, for the wind pressure that in a permanent building is almost negligible, is in a lightly-constructed building an important factor, and some means of

anchoring principals to supporting posts and to ground should be adopted; also ample wind bracing must be provided.

If the needs of the building call for large spans, queen-post trusses or constructions of the Belfast truss type will be found most economical, and the principal, so well applied in the latter and in recent war buildings, of using small scantlings bolted together should be generally applied, for lighter scantlings are always cheaper than heavy ones, and, moreover, can be moved without elaborate lifting appliances. (It is very doubtful whether any timber more than 2 or 3 ins. in thickness is needed for constructing temporary sheds even where an intermediate floor occurs.)

When corrugated iron is used rafters will be dispensed with, and even where boarding and glazing are employed a saving in cube timber can often be effected by placing the purlins closer together and by altogether omitting the rafters. Where, as in long slopes of glazing, purlins are necessary, care should be taken to assure that they will not bend or sag under the weight and thrust of the glass.

Eaves should, if possible, project a good distance over sides in order to protect work below from driving rains, and although such overhanging gives a greater possibility to wind lifting the building, this can be guarded against by the anchoring of the principals above referred to and by carrying down the supports into the concrete foundations.

Cast or galvanized iron eaves gutters will be most economical externally, and where internal gutters occur asphalt possesses many advantages over cast iron from the fact that no joints are necessary; for as is well known these are often the greatest sources of trouble in large single story buildings.

Where felt is used for roof coverings its employment for gutters is often urged, but owing to its short life it should never be used unless covered with asphalt.

In all cases where there is a possibility of removal and reconstruction, temporary buildings should be bolted and screwed together rather than spiked and nailed.

Movable Fittings.—The principle of standardization should as far as possible be applied to the design of all screens, fittings, and partitions between departments and to the foremen's and check offices, and they should be constructed and fitted together so that they may easily be taken down and refixed in new positions when extensions occur.

Strong steel angles used for fixings at floor and ceilings will be generally found most convenient. Where screens are needed for dividing off one part of a department from another wire or metal

mesh has many advantages over solid partitions, as by its use patches of stagnant air are greatly reduced, lighting is not impeded as by solid or even glazed screens and a saving in cost is effected.

In constructing the foremen's offices the floor should be 18 to 27 ins. above general factory level. Glazed sashes should be fixed on all sides in order that any part of the factory can be seen, and a sliding sash to do away with the necessity of constantly opening door is often very useful.

CHAPTER IX.

WAREHOUSE AND STORAGE BUILDINGS.

WAREHOUSES and storage buildings may be divided into four types :—

A. Buildings or sheds for storage of raw material.

B. Buildings for storage of finished articles.

C. Warehouses buildings not connected with the factory.

D. Buildings of the furniture depository class.

Space for storage of raw material and for the finished articles is generally required in all works, but in small concerns will generally occupy a portion of the factory. In this case the material, where of an inflammatory nature, should be as far as possible cut off from the manufacturing portion of the works by fire-resisting walls and doors.

Where, however, the business is a large one the provision of the separate buildings classed above under A and B will save much time and expense in the organization of the works and will greatly reduce fire risks. These buildings, especially the former, must be near to the factory, but should, if possible, be entirely distinct from it, and if covered ways are required, they should be open at sides and roofed with fire-resisting material.

In all businesses goods arriving and leaving the works must be checked and sometimes weighed, and small offices should therefore be formed both at entrance and exit gates, and where weighing is necessary weighbridges formed in front of these offices.

To deal with the special and different requirements of each and every trade is impossible, but the following rules apply in all warehouse and storage buildings :—

1. Stores should be placed so that raw material is as near as possible to that part of factory where it will be used.

2. Arrangements for removing any material in the stores without interfering with or moving other stores should be provided.

3. Where fittings or stacks of material occur the gangways must be wide enough to allow passage from opposite directions without temporary blockages.

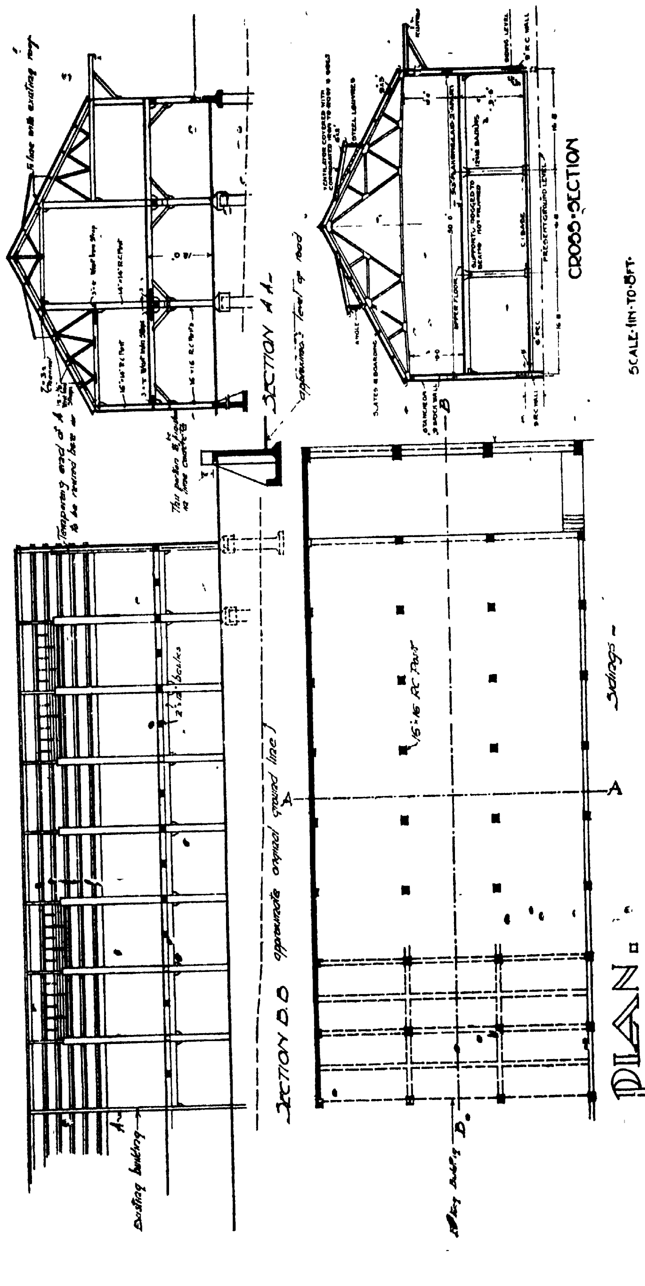


FIG. 18.—A woodstore building. (A. Alban Scott, Architect.)

Fig. 19.—The main craneway, The Ford Motor Co.'s works, Detroit, Michigan, U.S.A.

4. If weights dealt with are heavy, tramways or overhead runways should be formed, care being taken to make the beams supporting them strong enough to carry the moving loads that they will receive.

5. Where goods are of such a nature that they would if stored or placed leaning against a wall tend to push it over by their weights, either racks should be formed clear of walls or the walls themselves should be stiffened and constructed to receive such stresses, and reinforced concrete lends itself best for this purpose.

6. The sufficiency of light necessary for a warehouse is generally less than that required for a factory, and the placing of the windows high up will often provide valuable extra storage space.

7. The buildings should as far as possible be divided into self-contained units by brick walls, and the necessary openings between them closed with double fire-resisting doors.

In all storage buildings the outside jib crane for lifting goods to upper floors is not to be favoured, and the plan of forming cartways into building with floor at level of top of dray and with lifts adjacent is much to be preferred.

Where buildings are of class D, in which the goods may be left for long periods, the provision of an external lift with galleries leading to each floor will greatly reduce fire risk, and an example of such a building in which each floor virtually constitutes a self-contained building is shown in Fig. 74.

The construction of warehouses is somewhat similar to that of factories, and although each class of material will raise its own problems, the chapters on the factory are generally applicable to this class of structure.

CHAPTER X.

BUILDINGS FOR INDUSTRIAL AND SCIENTIFIC RESEARCH.

THE need for more scientific research in connection with British industry is generally admitted, and although research departments have for many years been the rule in some factories, their number in comparison with America and German firms has been small.

At the present time in America there are several manufacturing corporations spending sums up to £100,000 annually upon research work, and whenever a firm reaches a certain size, and feels the need of such research work, the building and equipment of its own laboratory follows as a matter of course.

Research work in the factory may be divided into four main sections:—

1. Testing and analysis of material, both raw and in finished state.

2. Research work carried on for improvement of existing processes.

3. Research work for the development of some new branch of industry.

4. Pure scientific research.

1. Testing and analysis of raw material, material in course of manufacture, and of the finished product is most commonly met with, for the testing of raw material is necessary to discover and eliminate the presence of foreign matters that would affect the processes carried out in the factory, or would spoil the goods manufactured.

Sometimes these tests must be very rapidly made, and as an example of the testing of material in course of manufacture, and of the speed with which it must be carried out, we may cite the elimination of phosphorus from steel. During the time that the sample is being cooled and examined, the charge of molten metal must be kept in the furnace, and where such tests are needed, the arrangements for carrying them out must be in close proximity to the works.

It must, however, be stated that the need for testing is in many

FIG. 20.—Engineering laboratory, National Electric Lamp Association, U.S.A.

trades almost eliminated, if raw materials are supplied by firms of high repute, and in such cases, unless the needs of the business warrant work under groups 2 and 3, a laboratory is unnecessary.

Again, the equipment of special testing apparatus is often beyond the financial means of smaller firms, and in such cases outside help is employed, for unless the laboratory is properly equipped and an efficient staff installed it is worse than useless.

2. Research work carried on for the improvement of existing processes has been too often lacking in British industry in the past, and there is little doubt but that the more thorough scientific investigations carried on by foreign firms has led to the partial loss of many of our markets, and has given the foreign manufacturer many advantages over the home manufacturer.

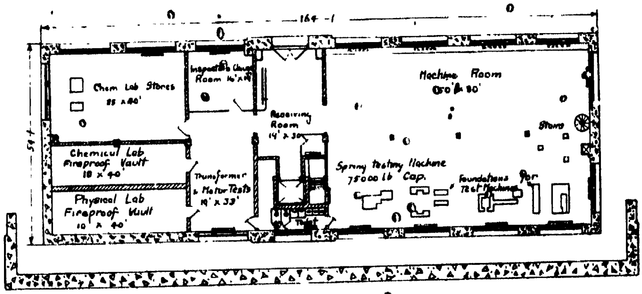
3. Research work for the development of some new branch of industry has been greatly developed during the past few years, and the results of scientific discovery will in the future play an ever-increasing part in the "production of many trades," and "production" is essentially the basis of national material prosperity.

In numerous cases the building in which it is carried out will become a factory in itself, equipped with all necessary machinery and tools for carrying through experimental products from raw material to its finished state, and in many works the profits on the sale of what is produced in the research building will entirely pay for its upkeep.

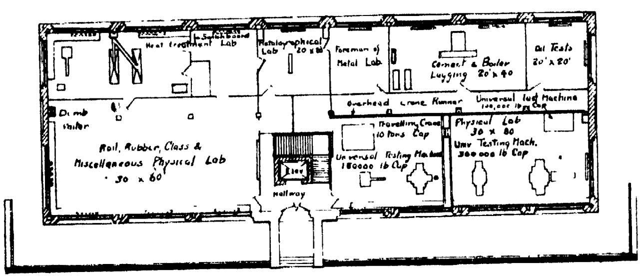
4. Pure scientific research is not generally expected to be carried out by industrial firms, but bids fair to become more common in the future, and the following extract from a recent Government publication dealing with American industry is noteworthy: "Among the most progressive firms there is a growing appreciation of the fact that almost every discovery in science ultimately may have influence on industry. Such firms devote increasing attention to research of this character, and in some cases special laboratories have been installed quite distinct from the ordinary research laboratory for this purpose. This may be viewed as a very far-seeing business policy, directed to outstripping competition by the continuous provision of discoveries, which may sooner or later be turned to industrial account. It is recognized that in such cases there is a probability of a great deal of the new scientific knowledge thus obtained being only of limited use to the particular industry concerned. On the other hand, one successful discovery may result in such important industrial gains as to outweigh by far the cost of all the abortive research."

The plan of the works laboratory will entirely depend on the

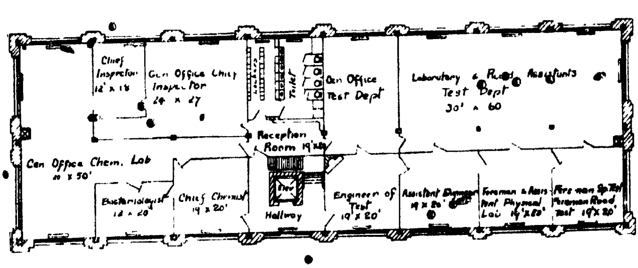
investigations to be carried on, and no two buildings are likely to have the same requirements, but there are certain matters that apply in all buildings devoted to scientific research.



BASEMENT PLAN PRC



FIRST FLOOR PRC



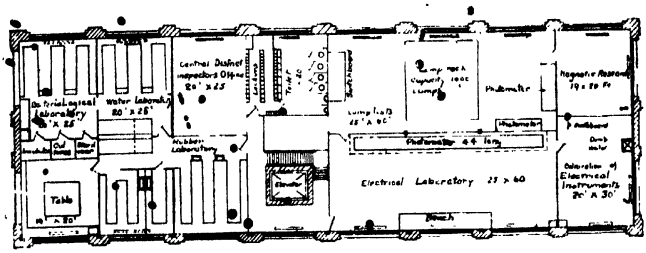
SECOND FLOOR PRC

FIG. 21.—A research laboratory.

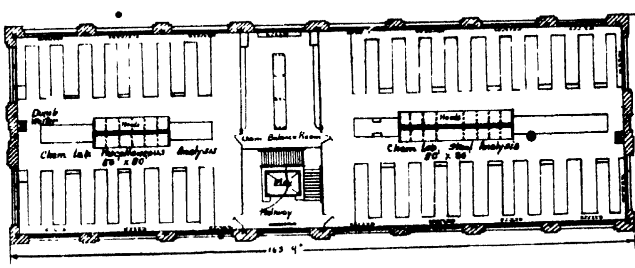
Before dealing with them, however, it must be stated that co-operation of the architect and the works chemist or physicist is essen-

tial if the building is to be a success, and is to fulfil the requirements, of the works at a minimum cost, and without constant alterations.

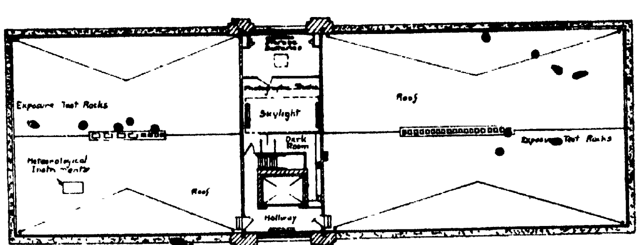
Sketches showing position of all fittings, ducts, vents, etc., should



THIRD FLOOR PRC



FOURTH FLOOR PRC



FIFTH FLOOR PRC

FIG. 21A.—A research laboratory.

be made, and discussed with a view to future and extended uses, and until the research staff have formulated their scheme of working, no final drawings should be commenced.

In the design of the buildings, the chemical laboratory should occupy the topmost floor of the building, and lantern or roof-lighting should be provided in addition to the windows in external walls, also, in close conjunction with this laboratory a balance-room and store for chemicals should be provided. A room for the chief chemist is

FIG. 22.—Research laboratory, Westinghouse Co., U.S.A.

necessary, and in large blocks a smaller laboratory and one or two separate offices are needful.

The physical laboratory should occupy the floor below, and be easily reached from the chemical department, but where heavy testing occurs, it should be carried out on lowest floor, and in some trades

a special building may be necessary to prevent vibration in the rooms where delicate experiments are being performed.

Space for a library or reference-room, and stores for apparatus and general records should always be arranged for, and the construction of several ducts below the floors, especially in the chemical

FIG. 23.—Vapour convertor research employing works equipment, Westinghouse Co., U.S.A.

department, will save many alterations as more and more pipes and wires are installed in the building.

Vibration must be reduced to a minimum, and a monolithic building of reinforced concrete will generally give better results than one of brick and steel construction, and in all departments where

corrosive acids are used, exposed metal work should be avoided, and teak or hardwood used for frames, doors, etc.

The Chemical Laboratory, as before stated, should be on top of building, and should be cut off by cross-ventilated lobbies so that

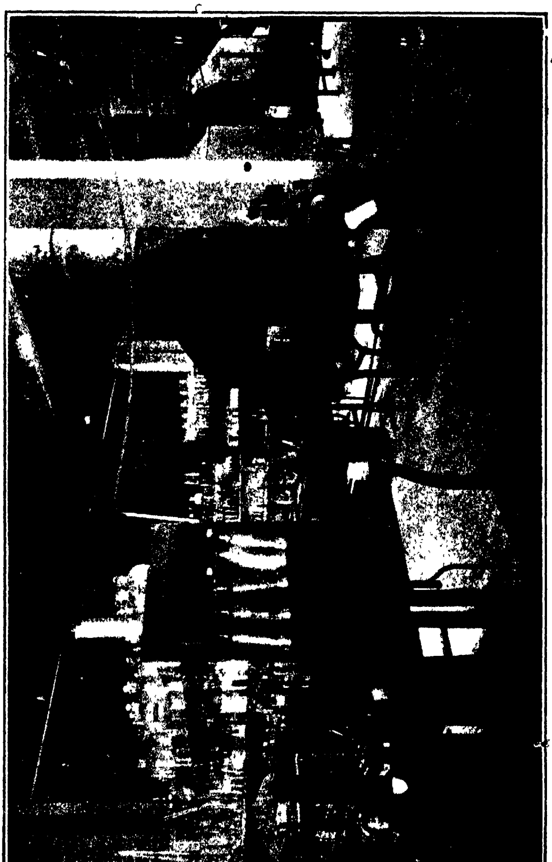


FIG. 24.—Chemical laboratory, Westinghouse Electric and Manufacturing Co., U.S.A.

smells and fumes are prevented from spreading to other portions of the structure. The walls should be of white or cream glazed bricks or tiles, and doors and window frames enamelled so that the whole room can be washed down at intervals.

Teak blocks about 2 ft. apart built into walls every 18 ins. in

height are often found very useful for fixing apparatus, etc., both in the chemical and physical laboratories.

The windows and skylights should be made to open, and may be glazed with clear or translucent glass, but all coloured glass must be

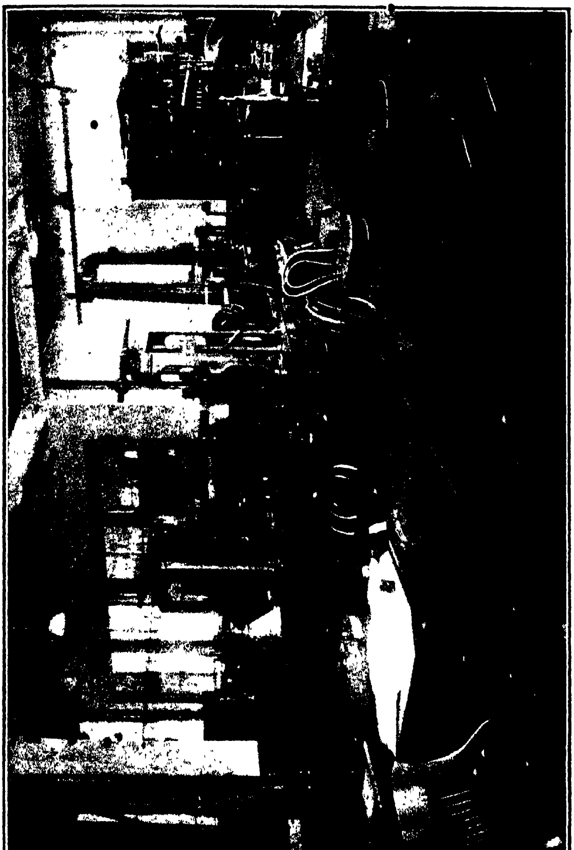


FIG. 25.—Physical laboratory, Westinghouse Co., U.S.A.

excluded, as light passing through it might interfere with the work carried on in the building.

The flooring material will greatly depend on the uses of the room. If wood is used hardwood blocks are best, but of whatever material it is made of, anything that tends to wear dusty must be avoided.

In large electrical laboratories, where battery-rooms are needed, the floor should be of asphalt.

A floor-covering used in some American laboratories is rezalite mastic, which is a preparation of elaterite containing some asbestos fibre, and is superior to asphalt as it gives elasticity to the floor and at the same time does not yield under the weight of heavy furniture.

The ducts under floor carrying pipes and wires, chemical drains,

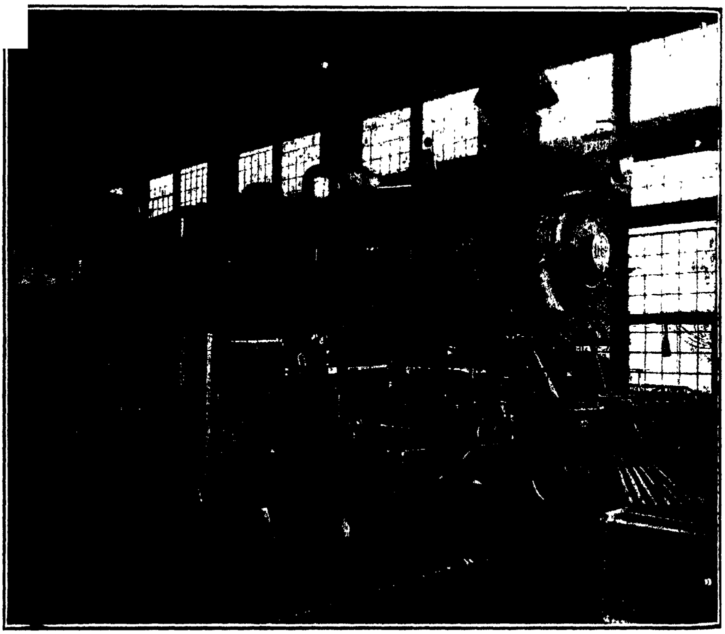


FIG. 26.—Locomotive testing laboratory, Pennsylvania Railway Co., U.S.A.

etc., should be fitted with easily removable covers for their whole length, so that faults and leaks may be easily located and alterations easily made. The bottom of ducts should also be laid to a slight fall to a catch-box gulley.

The sinks, waste pipes, and chemical drains should run to a cesspit with movable inspection cover, so that any foreign substances may be intercepted before falling into drains or sewers.

Fume cupboards are generally necessary and should if possible be fixed against a wall. Their base should be formed of a thick slate

slab and the glazed enclosure should be constructed to eliminate all corners in which stagnant air might remain.

Outlets connected by glazed stoneware pipes to a duct with fan or other means of withdrawing the vitiated air are necessary.

The design of special ovens, closets, etc., must be settled with the works chemist, but a large porcelain sink, fitted with hot and cold water and with large draining boards at either side and rack over, is necessary for washing apparatus.

FIG. 27.—Works laboratory, Messrs. Cadbury Bros., Ltd., Bournville.

The Balance Room must be as far as possible free from vibration, and should be cut off from the laboratory so that fumes and gases cannot enter therein. Where very delicate work is carried out the balance should rest on a stone or reinforced concrete pillar carried up from foundations and kept entirely free from the remainder of the construction of the building. This may be effected by forming the pillar in a well with a space left around it where it passes through balance-room floor, but where this is impossible or the work does not necessitate such extreme accuracy the balance may stand on a shelf

built into and resting on brackets fixed to walls, but in no case should the balance table be supported from floor.

Storerooms should be of ample size fitted with drawers, bins, and shelves, and in large buildings an adjoining room for the special apparatus maker should be provided.

The Physical Laboratory and Balance Room should be generally constructed as in the chemical department, and if top light can be obtained it is often an advantage.

As experiments needing total darkness are often necessary in this department, a dark-room should be built, but if this cannot be arranged or is not justified, light-tight shutters should be formed to all windows and skylights. Perfect blackness is most easily obtained where the dark-room is built within the structure away from all external walls, but where it is on an external wall a northern aspect lends itself most easily to being darkened by black blinds running in light-tight grooves at either side of window.

The Store should enter from the physical laboratory, and where very delicate or bulky apparatus is used special means must be devised for moving and placing apparatus in position. This, however, so much depends on the type and use of building that it can only be individually settled with the research workers.

The heating and ventilating of the building need careful consideration, for every possible means must be taken to exclude damp and dust from the building, and a "plenum" system in which the air is washed and warmed before entering the building is generally most satisfactory.

In conclusion, it may be urged that as industrial research bids fair to occupy a still greater part in the organisation of the factory of the future, all buildings for this work should be designed to allow for the possibility of future extensions.

CHAPTER XI.

WELFARE WORK AND WELFARE WORK BUILDINGS.

VARIOUS matters dealing with the development of welfare work in the factory have already been dealt with in previous chapters, but its ever-increasing influence in the design of industrial buildings, and the distinct departments that are necessitated for its application, make it advisable that a separate chapter should be devoted to them.

A generation or so ago the factory and its organization was looked upon as the peculiar and especial property and interest of the employer, and was built with a view to create wealth for himself alone, and provided that he paid the wages due to his workers, it was generally assumed that his duties towards them were fulfilled. Little by little Factory Acts and social legislation had raised the standard of hygiene and decency in the works, the influence of model employers, such as Messrs. Lever Bros., Messrs. Rowntree, etc., was spreading, but the coming of the war with its contingent reports by the Health of Munitions Workers Committee and other bodies, together with the powers given to the Home Secretary, have given an impetus to all phases of welfare work dealing with the factory and its workers.

So much is this so, that the superior person who formerly sneered at welfare work is now quite alarmed, and is raising the cry that welfare work is being overdone, and that industrial ruin will follow in its footsteps. The best answer to this is the practical one that American firms, who are generally very wide awake, have done and are still doing more and more for their workers; not only on charitable grounds but because they find it pays, and as instances we may quote such firms as The Ford Motor Co. and The National Cash Register Co., whose developments are of world-wide renown.

Turning now to British firms, it is found that those doing most for their workers are those ranking among the most prosperous businesses of the country, and the experience of the firms who have made a study of the subject in their own works is: that welfare work

is not a gratuitous charity on their part, but is, on the contrary, an investment that in the long run more than pays for itself. They have proved that pleasant working conditions and contentment in the factory have eliminated many of the petty troubles that have in the past led to friction and consequent delay in production, and, moreover, that their workers are not so easily tempted to leave them and to transfer to a rival firm. This last point is often not appreciated at its true value, but when it is realized that in many trades

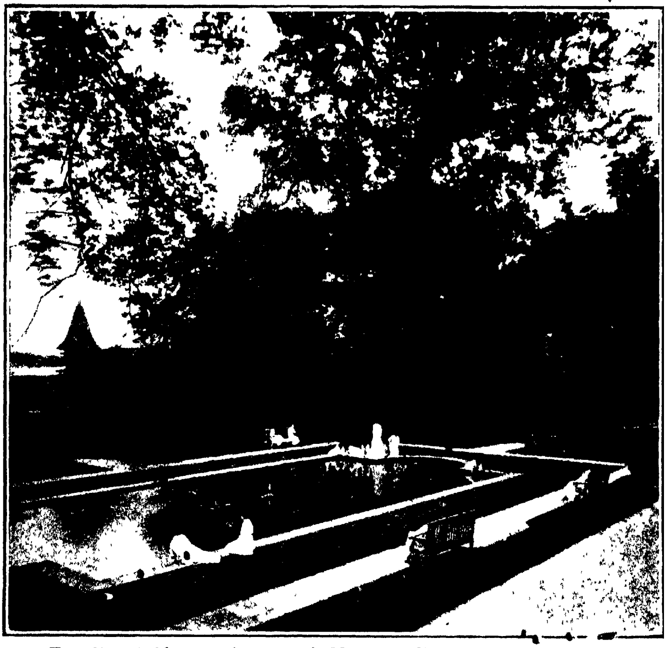


FIG. 28.—Girls' recreation ground, Messrs. Cadbury's works, Bournville.

several weeks are often spent in training a worker to carry out some process, and that during that time the firm is paying wages, the investment of a further sum to keep such trained hand is but a sensible business proposition, and is met by many firms by setting apart an annual sum for each employee; this sum being spent in entertainments, outings, and instruction in outside subjects, etc.

It would be easy to fill a large volume with descriptions of what is being done at Port Sunlight, Bournville, and York, and the illustrations will exemplify the scale on which these firms are working,

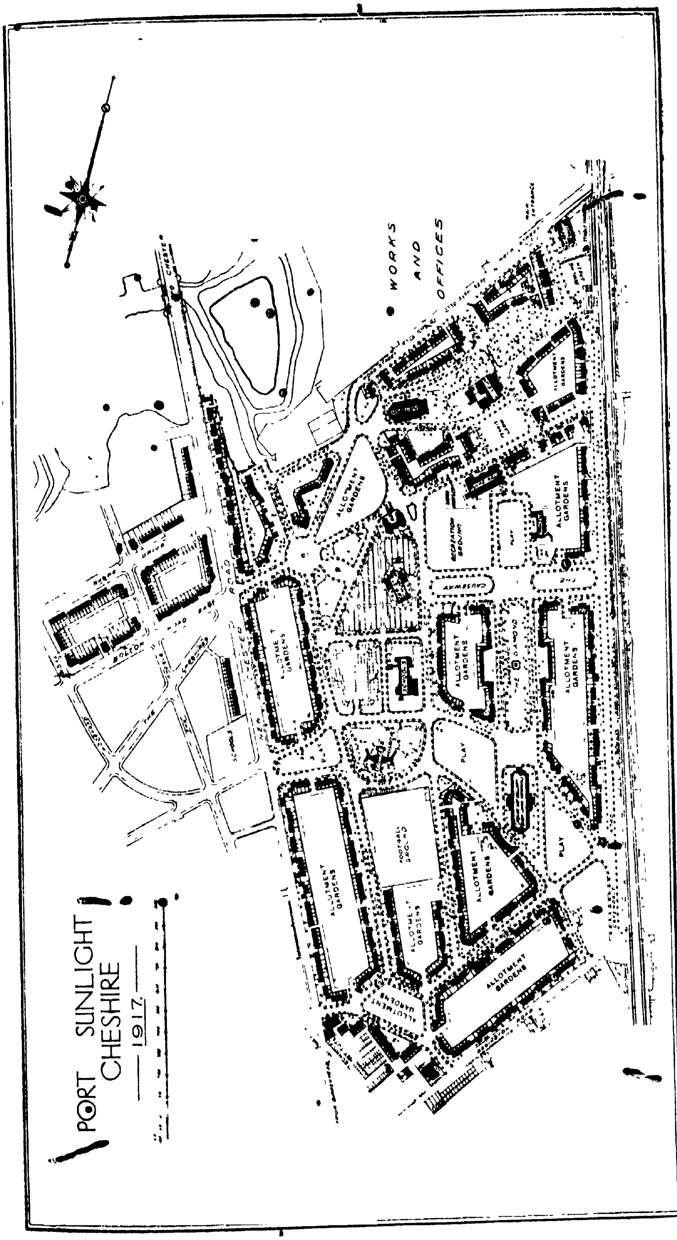

PORT SUNLIGHT
CHESHIRE
1917
WORKS AND OFFICES
ALLOTMENT GARDENS
RECREATION GROUND
PLAY
CAUSEWAY
SCHOOLS
FOOTBALL GROUND

Fig. 29.

but as an example of a smaller firm the following description of the system in vogue at The Spirella Manufacturing Co.'s Works at Letchworth (where about 600 persons are employed) is interesting:—

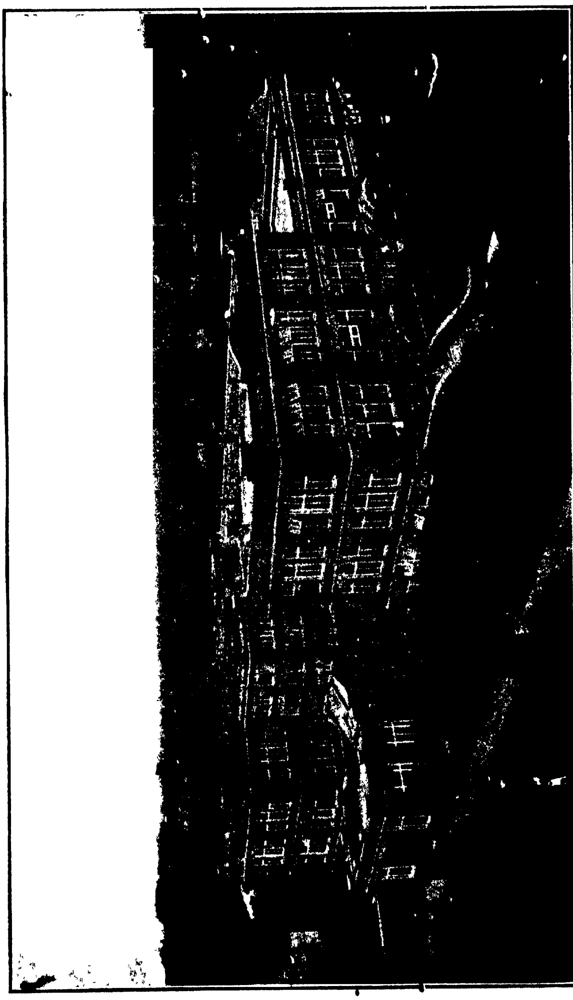


FIG. 30.—Welfare buildings, Messrs. Rowntree & Co., Ltd., York.

Bathrooms are provided, and each employee—both male and female—has the privilege of taking one bath in the company's time each week.

Library and Rest-room.—A complete first-aid equipment is provided, with accommodation sufficient to meet all ordinary demands, the nurse being in constant attendance. The nurse also acts as librarian in supplying books for reading during the noon hour for all those desiring them after having luncheon on the premises, also lists books loaned for home reading. There are now in the library approximately 1200 volumes. A number of suitable and attractive

FIG. 31.—Girls' hospital, Curtis Building, The Curtis Publishing Co., Philadelphia, U.S.A.

periodicals are placed in the library each week or month, and writing materials are also supplied.

Eye Welfare.—This is a new welfare movement that has been recently organized, and promises to be one of the most helpful. An optician has been engaged to visit the works once every week, in order to examine the eyes of employees, and to make recommendations as to their needs in the way of eye support through glasses or through change of work; or whatever may be best for the individual. It is expected that a great deal of good will result from this, and

already many corrections have been made in case of those wearing glasses that were unsuited to them. Many workers who had need of glasses and were not wearing them have been supplied, to the mutual benefit of themselves and the company.

Dining and Refreshment-room.—Refreshments are supplied

FIG. 32.—Works surgery. Messrs. Cadbury Bros., Ltd., Bournville.

at cost of the food and drinks to all employees at least once daily, and all overhead expense is borne by the company.

Staff Training.—Classes in corsetry, salesmanship, and letter writing are carried on, also classes in shorthand and typewriting, in which classes many of the present operators have been trained.

Junior office workers also attend classes for arithmetic, book-keeping, general commercial practice, essay writing, etc.

General Service.—In the matter of general service, where all employees have an opportunity to contribute who desire to do so, there is maintained by the women a needle service guild, constantly

Fig. 33.—One of works surgeries, Messrs. Lever Bros. works, Port Sunlight.

preparing and sending comforts to soldiers, not only including boys who have gone from the factory, but others introduced by members from time to time. This guild also co-operates with the local Guild of Help in looking after the welfare of many families in the district.

Recreations.—Clubs for golf and tennis, an elocution and dramatic class, and classes for dancing, singing, needlework, and physical culture, are provided, and a large concert hall with seating accommodation for 1000 persons, and fitted with proper stage and dressing-rooms has been erected, and is shown in Fig. 55.

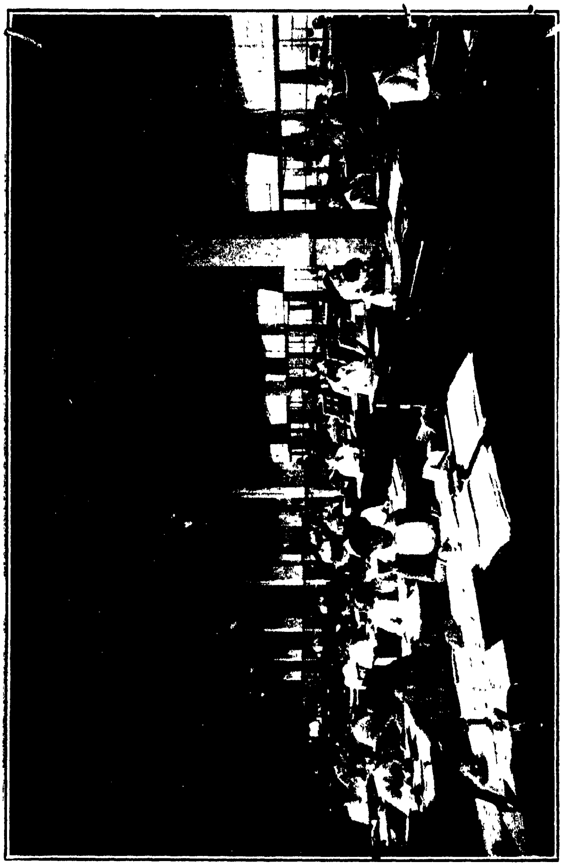


FIG. 34.

The description of all the types of welfare buildings now in vogue is beyond the scope of this work, but there are two, first-aid rooms and canteens, that are now so integral a part of the factory, that they merit a place in any volume dealing with factory buildings.

First-Aid Rooms.—The first-aid room should be at least 12 ft.

by 10 ft., and of good height. It should be entirely finished in hospital manner with rounded angles and corners, and the junction of walls and floor should be made with a curve at least 2 ins. radius.

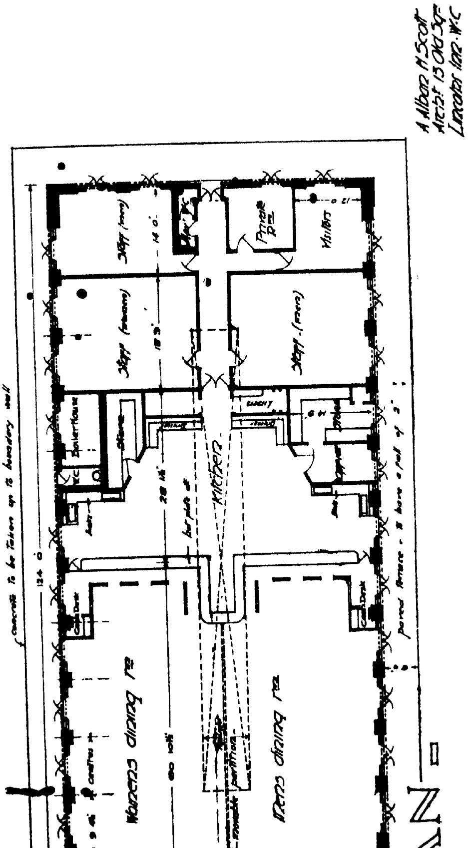


FIG. 35.—A canteen.

Good natural lighting is essential, and besides the indirect artificial lighting, plugs for both light and power should be provided.

For the floor jointless material is best, and the ceiling should be

enamelled white or finished in some material that can be washed down. The walls may be of tiles, glass, or hard plaster enamelled

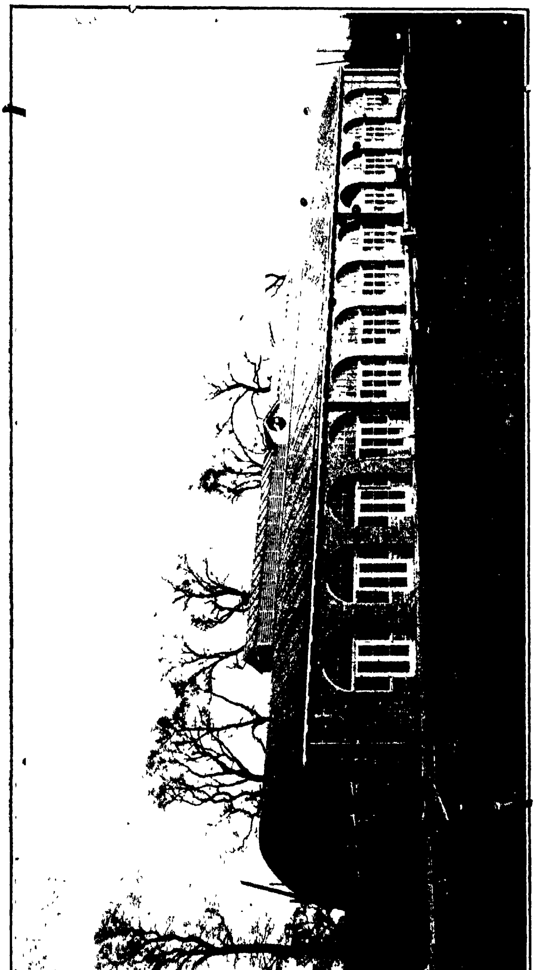


FIG. 36.—Exterior of canteen. (A. Alban Scott, Architect.)

white, and all fittings should be capable of frequent cleaning so that the apartment may be perfectly antiseptic.

Large roomy cupboards for drugs, etc., must be provided, and in

large works a separate store fitted with sink and supplied with hot and cold water is a desirable addition.

Canteens.—The Health of Munitions Workers Committee appointed by the Ministry of Munitions has issued several reports on industrial fatigue and on canteens, and these (especially those numbered 3 and 6) should be read by all interested in this subject.

It is self-evident that productive output in regard to quality, amount, and speed is largely dependent upon the physical efficiency

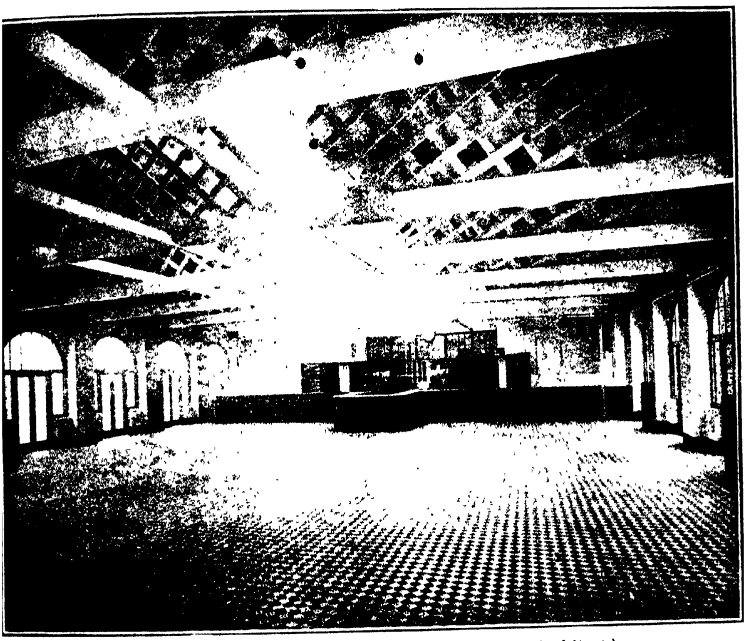


FIG. 37.—Interior of canteen. (A. Alban Scott, Architect.)

and health of the workers, and these facts are well borne out in the concluding paragraph of the above report, which states: "The Committee have been impressed with the consensus of opinion which they have received as to the substantial advantages both to employers and workers following the establishment of an effective and well-managed canteen. These benefits have been direct and indirect. Among the former has been a marked improvement in the health and physical condition of the workers, a reduction in sickness, less absence and broken time, less tendency to alcoholism, and an

increased efficiency and output; among the latter has been a saving of the time of the workmen, a salutary though brief change from the workshop, greater contentment, and a better mid-day ventilation of the workshop. The Committee are satisfied that the evidence of these results is substantial, indisputable, and widespread. In the

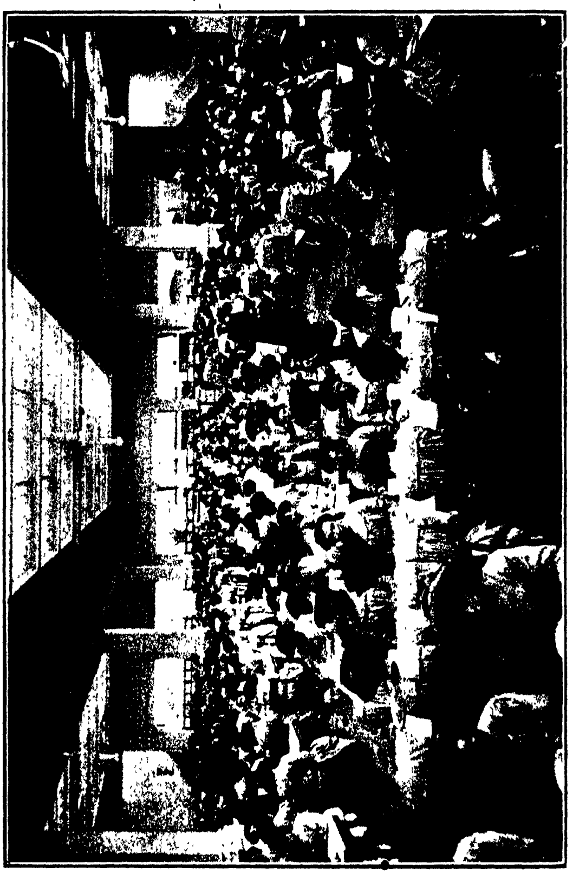


FIG. 38.—The girls' dining-room, Port Sunlight.

isolated cases where the canteen has failed it has been evident that its failure has been due to exceptional circumstances, misuse by the workers, or mismanagement. In almost all large works the Committee find that there is a body of men or women (averaging at least 25 per cent) who, in the interest of physical health and vigour, need

canteen provision at the factory. They are convinced that this group of ill-fed workers accounts in a large degree for such inefficiency as exists, and that its energy and output is reduced in the absence of suitable feeding arrangements."

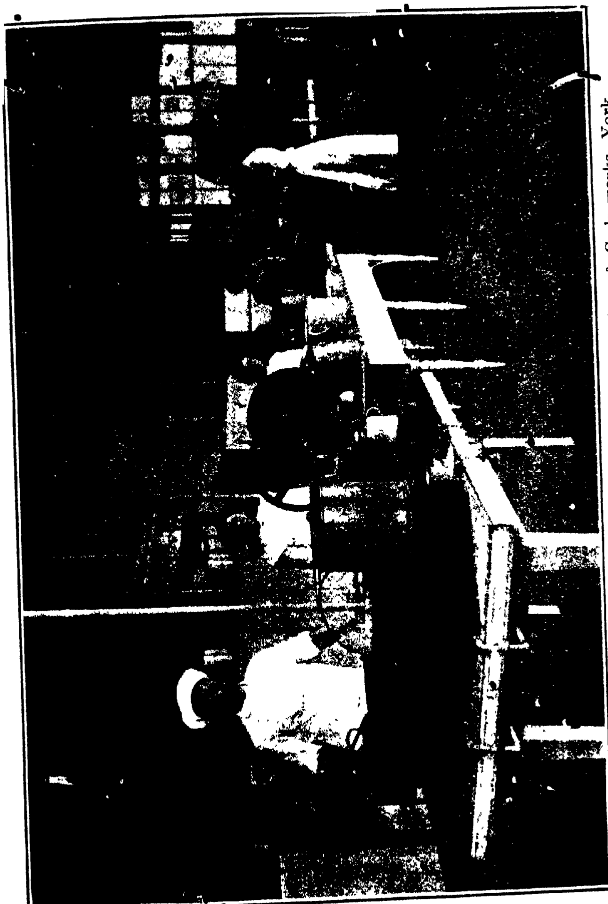


FIG. 39.—The kitchen in dining-rooms, Messrs. Rowntree & Co.'s works, York.

Generally and Site.—The desirability of making the canteen a separate building has already been mentioned, and bearing in mind the tendency for the canteen to become the "Workers' Centre," allowance should be made for possibility of extensions beyond those needed for normal factory increase.

When a scheme for works is being prepared the settlement of the site for the canteen must, of course, be secondary to the factory itself, but a position having pleasant outlook should be given to it, and the dining and rest-rooms should, as far as possible, look away from the works.

Sanitary conveniences, except for the staff, are not desirable in the canteen building, and should be placed in a block by themselves, and where a sanitary tower or block is provided outside the factory

FIG. 40.—The works kitchen, Messrs. Cadbury Bros. works, Bournville.

and cut off from it by a road, the desirability and economy of placing the canteen on the opposite side will be at once apparent.

Canteen buildings may vary from simple dining-rooms with kitchen and store to halls such as that at Port Sunlight, which is shown in Fig. 38, but the following are the minimum that should be included in any scheme.

1. Dining-rooms for each sex with separate rooms for clerks and foremen.

2. Kitchen with wash-up adjoining.
3. Larder.
4. Store.
5. Office for manager.
6. Staff-room.
7. Conveniences for staff.

Where it is possible, the following should be added, and arrangements for throwing two or more into one room suitable for meetings or concerts should be made by forming some divisions with sliding or removable partitions.

8. Rest-rooms for both sexes.
9. Verandahs.

Plan.—Everything goes to prove that the canteen has already become a part of the normal factory organization and the building should therefore be of permanent construction.

Several methods of service have been tried, but so far the general consensus of opinion is that the most economical and speedy service is obtained where each worker fetches his own food from a counter or hatch and carries it back to the table.

Where but one dining-room is provided the kitchen should be placed at side rather than at end of building, so that no worker has to walk the whole length of room to fetch his food. If two or more dining-rooms are required, the kitchen should occupy the centre of the block, but ample space should be left on one side for the larders, stores, etc., and for entrance of staff and goods.

Barriers should be fixed in front of the counter or hatchways, so that each worker is served in his turn, and the counter should occupy as great a length of one side of dining-room as is possible, for very quick service will be expected by the workers and is a necessity where only a short time is allowed for a meal.

Entrance lobbies should, if possible, be formed between dining-room and open air, and where entrance is on north or east side, the provision of a screen around door will prevent draughts blowing on persons near entrance.

A buffet from which workers can obtain tea, coffee, or confectionery will be found useful in large dining-rooms, and where rest-rooms are provided it may be found possible to place it so that it serves both dining and rest or recreation-rooms.

The Kitchen, whether in middle of building or not, should be top lighted, and a central lantern with centre-hung sidelights will be found best, both for working and as a help towards ventilation.

Cooking apparatus may be by means of steam, gas, coal, and

electricity. All systems have their champions and possess certain advantages, but the first will be found most expensive to install, and where electricity is generated in the works the provision of the latter has many advantages.

A small paved yard should be provided near kitchen entrance, and in it a pig trough for waste food and scraps should be placed, also to prevent the accumulation of refuse a small destructor will be found to be desirable.

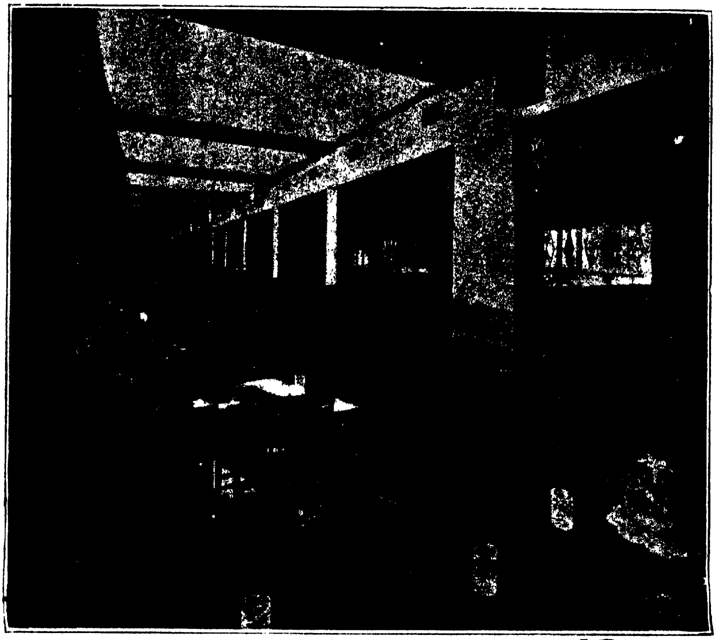


FIG. 41.—Girls' dining-room, Curtis Building, The Curtis Publishing Co., Philadelphia, U.S.A.

The wash-up or scullery should adjoin kitchen, and a hatch formed at end of counter so that dirty dishes may be passed direct into it.

Separate vegetable and washing-up sinks should be provided and ample supply of hot water arranged for. This may be provided by a large gas geyser or water-heater, but where a boiler-house for heating is installed, the provision of a hot-water system is preferable and more economical.

The Larder should have windows facing north, or north-east,

and either part of the panes should be filled with perforated zinc panels, or permanently open ventilators should be built into walls, which latter should be lined with glazed bricks.

Floors should be of hard impervious material and all shelves of slate or of artificial stone enamelled white.

The Store must be provided with large bins and shelves, and to save wall space, windows may be formed high up and near ceiling.

FIG. 42.—Girls' recreation-room, Curtis Building, The Curtis Publishing Co., Philadelphia, U.S.A.

Floors of wood blocks are to be preferred for this room, and all woodwork should be enamelled white, and mouldings avoided.

In large canteens the provision of a second storeroom for spare cutlery, crockery, etc., will be found useful.

The Office for the manager or manageress should be placed to give as far as possible supervision over the kitchen staff, and goods entrance, larder, and stores. If possible, a fireplace should be provided in this room, and it should be finished as an office and sitting-room combined. Where its walls abut on to any of the other

departments, glazed panels with sliding shutters or curtains should be formed, so that supervision is as far as possible obtained without leaving the office.

A Staff-room must be provided with conveniences for both sexes when men and women are employed in the kitchen staff, and in the latter case, either separate staff-rooms or small dressing-rooms where clothes may be changed are a necessity.

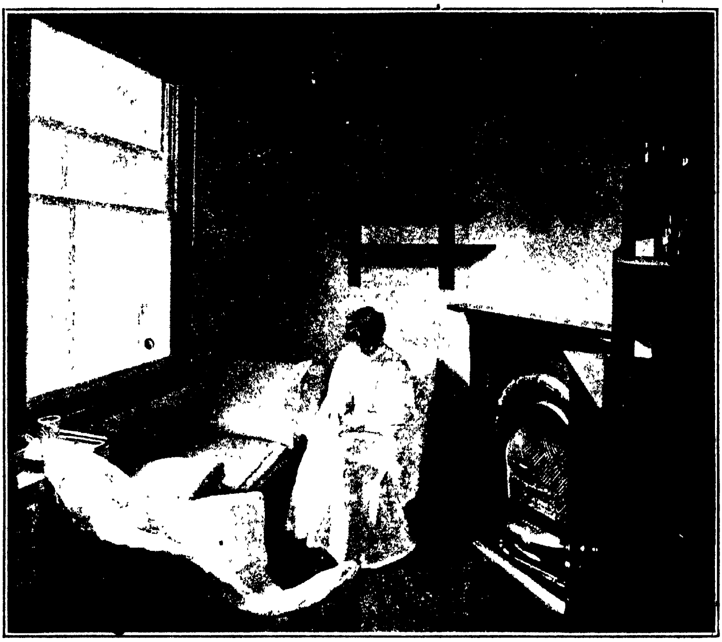


FIG. 43.—A girls' rest-room, Messrs. Cadbury Bros. works, Bournville.

Rest-rooms should be near dining-room, and have entrances to verandahs where these are provided. Where this is the case, it is a good plan to form all, or alternate windows looking on to verandah as doors opening direct to it, and this arrangement will in the summer-time greatly help to keep the atmosphere of the dining-room fresh and cool.

Walls of brickwork, or of reinforced concrete piers with brick-filling for panels, will in most cases be best, and windows should occupy at least one-fifth of the floor area.

For window-frames, either wood or steel sashes may be used, but the latter will not only reduce fire risk, but will allow for better ventilation, and also reduce maintenance charges.

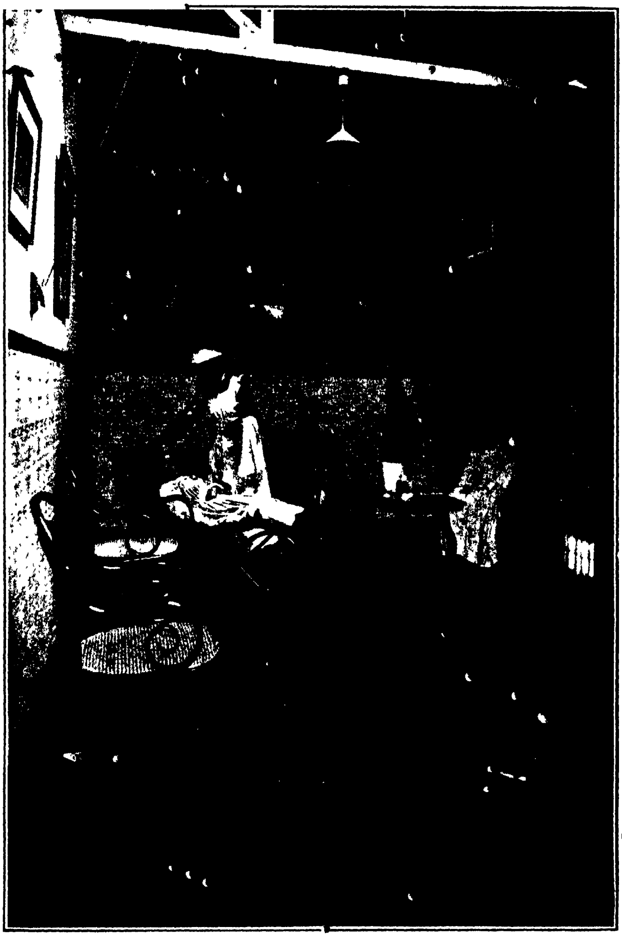


FIG. 44.—The girls' rest-room, Port Sunlight.

Floors.—The floors of canteens have so far caused the greatest difficulty, and experience has proved that wood should not be used. Where, as is usual, the worker fetches his food from the service

counter, spilling of liquids is sure to occur, and scraps of food falling on the floor are trodden upon, so that after a few months the appearance and atmosphere of the room becomes objectionable.

To-day opinion is in favour of one of the following:—

A. Concrete, finished with either grano, a surface of cement, and a floor finish or asphalt.

B. Concrete with linoleum laid direct upon it.

C. Tiles, terrazzo, or jointless flooring.

Of these, A and C are to be generally preferred, as by their use the floors can be laid to a slight fall, to a channel against wall, and as often as necessary the whole surface can be washed down with a hose, and scrubbed with rubber brushes.

Roofs should be open up to collar beam if not to ridge, for the benefit of the increased height gained greatly helps towards giving a better atmosphere whilst building is in use.

Owing to war conditions, the use of timber principals or lattice constructions of Belfast truss type have been of late common, but to reduce the risk of fire, steel or concrete principals are to be preferred.

Concrete flats with asphalt coverings are relatively expensive, and pitched roofs covered with slates or tiles will not only be cheaper, but will tend towards a more effective appearance and grouping of the whole industrial block, and the psychological effect of taking the workers into a different type of structure during rest times will be found to be beneficial both to them and to the employer.

Lighting.—Windows should be glazed with clear glass and artificial lighting arranged as in the factory by indirect methods.

The Ventilation of canteens is a difficult problem, and unless an expensive system is installed, louvres controlled by rods or cords should be fixed on ridges and fans provided to keep air in motion.

The provision of dormers with opening sashes will also help towards keeping the atmosphere fresh, and will tend to give a brighter appearance to the rooms.

The Heating System of the buildings will depend greatly on its use. Where it is often used by workers after factory hours the installation of a low-pressure hot-water system will be found most economical, but where it is only used at meal times the heating and ventilation will be best effected by the installation of apparatus for driving hot air into the building.

Fire Prevention.—The danger arising from outbreak of fire should be minimized by constructing as far as possible with fire-resisting materials, and if an outbreak does occur, the provision of

the large windows opening on to verandah should enable the building to be cleared in a very short time.

Hydrants should be installed as in the factory, and the decoration of the building by paper rosettes and festoons should be prohibited.

Where iron flues or pipes from cooking or heating apparatus are carried through roof, arrangements must be made to insulate pipes from roof-boarding.

The Finish of the canteen should be of materials that may be readily washed down, but simple schemes of colour should be arranged on the walls, fittings, and woodwork.

Care ought, however, to be taken to make these schemes quite distinct from those in the factory in order that the workers may as far as possible forget the factory for a time, and thus return to work refreshed both in mind and body.

Everything that tends towards this should be favoured by the employer, and rules therefore should as far as possible be conspicuous by their absence.

Experience, especially in America, has proved that the more the factory can be humanized the better will be the industrial results, and what is of far greater importance, an advance will be made towards the evolution of the perfect state.

CHAPTER XII.

FIRE PROTECTION OF FACTORY AND INDUSTRIAL BUILDINGS.

THIS subject was briefly discussed in Chapter IV., and although every building will raise problems of its own there are certain matters that are common to most industrial buildings worked under normal conditions.

That the danger of loss of life owing to panic is quite as great as that arising from fire should always be remembered, and whatever may be the uses of the building it is the duty of the architect to so design it that the "risk" both to the workers and the goods manufactured in it is reduced to a minimum; for although it is of paramount importance that its plan must conform to the requirements of the trade to be carried on in it, yet the exercise of careful thought in choice of materials and fire protective methods may eliminate many dangers, and at the same time reduce the insurance company's ratings.

In making a report on any building the fire surveyors will take into consideration many factors, such as local fire service, water supply, width of street in which property is situated, and the uses of the adjoining property. These matters cannot be controlled by the designer of the building, though they should influence his design, but apart from them the most important matters affecting the surveyors' report will be the construction of the building itself and its inherent possibilities of localizing any outbreak of fire.

A building may be exposed to danger both internally and externally, but the risk from the latter is in most cases almost negligible, and unless a structure abuts on works where highly inflammable trades are carried on, or is in close proximity to a timber yard, no special protection is generally called for.

Where, however, this is the case the party walls should not be unduly recessed, and should, especially next flat roofs, be carried up higher than is required by the Building Acts, and no window or openings should be formed facing the "exposed" danger unless they are absolutely necessary.

Where this is the case windows should be glazed with fire-resisting glazing, and all doors formed of teak, or if of soft wood externally sheeted with iron, and in cases where windows look into narrow streets or courts the same precautions should be taken, or shutters that will resist fire fixed and kept in working order.

The majority of fires, however, are caused by outbreaks within the building, and loss of life by fire or panic and destruction of plant and material can be most easily guarded against by the following means:—

1. The use of fire-resisting construction and the provision of fire-resisting enclosures and doors to all openings running from floor to floor.

2. The division of the building into blocks cut off from each other by fire-resisting double doors with spaces between them.

3. Provision of ample staircases and exit ways.

4. The installation of sprinklers, hydrants, or other methods of fire-extinguishing apparatus.

5. Periodic testing of all services within the building likely to lead to fires and explosions.

6. Periodic fire drill of all persons employed in the building.

7. Provision of adequate lightning conductors.

1. **Fire-resisting Construction** has been already dealt with in Chapter IV., but it is not generally realized how great may be the risk of fire spreading in a structure the shell of which is entirely of fire-resisting materials.

Apart from the goods within the building, the fixing of soft wood partitions and fittings, the laying of floor boards on fillets with a space below them, the use of lifts running from floor to floor, and the formation of soft wood lanterns and skylights may reduce a so-called fire-resisting structure to a type of furnace which once lighted causes everything within it to be consumed.

For this reason hardwood or fire-resisting materials should if possible be used for partitions and fittings, and all lanterns and roof glazing bars should be of teak, iron, or concrete, and the latter is in many ways preferable.

Spaces between floor boards and concrete should be avoided, and if a wood floor is needed blocks laid direct on prepared concrete should be used. The spaces between fillets where these are used are often left by the builder filled with shavings, sawdust, etc., and beyond this, spaces that cannot be reached tend to make a building anything but hygienic.

Openings to lifts and stairs should be fitted with self-closing

fire-resisting doors, and the lift-well should be encased with fire-resisting material of which brick or concrete is best.

For windows, steel sashes are to be preferred to wood, as by their use risk of fire damage is lessened, and all lintels over both windows and doors should be constructed of fire-resisting material that will not be affected by the sudden application of a stream of water delivered from a hose nozzle at a high pressure.

FIG. 44A.—Concrete and glass lantern.

The use of wood principals and roof construction over an otherwise fire-resisting structure should be avoided, and now that methods of forming roof principals in reinforced concrete have been so much improved, these with a concrete roof slab are much to be preferred to steel principals and purlin cleats, with purlins, rafters, and boarding of timber.

In all buildings where many workers are congregated near roof or where roof may be used by them, the provision of parapet walls is preferable to overhanging eaves, and where a roof slope and flat are

used a railing should always be fixed a little distance back from the junction of horizontal and sloping portions of roof.

2. The division of every factory building into blocks of 250,000 cub. ft. is with comparatively few exceptions insisted upon in London, and if the London Building Act was extended to the whole country the annual loss of life and property from fire and panic would tend to be greatly reduced. (Apropos of this matter the abandonment of the various Bye-Laws existing and their substitution of the London Building Acts as a National Building Act, subject to discretionary powers being given to certain districts, would in the main lead to more economical building.)

The various blocks of the building may be united by openings fitted with double iron doors, but care should be taken that these doors are kept well oiled and that nothing is allowed to stand in the way of preventing them from being closed at any moment, and they should ALWAYS be closed when the building is empty.

Where the limit of 250,000 cub. ft. can be proved to be detrimental to the trade or business for which the building is constructed, power is given under the General Powers Act, 1908, to build to greater cubical extent, providing that the height of structure is less than 60 ft. and that certain conditions depending on use of building are complied with.

3. Staircases were partially dealt with in Chapter IV., but the following matters deserve further attention :—

Permanent constructed staircases as alternative means of escape are to be preferred to movable fire escapes, for if the latter are installed they are very likely to be missing from possible exit point when required, or the position in which they could be used is blocked by goods or even machinery.

Cupboards under stairs are always inadvisable, and if used should be encased at sides with fire-resisting walls and fitted with teak or iron doors. Such suggestion may seem extravagant, but it should be remembered that a cupboard fitted with inflammable materials may by the smoke and heat generated in case of fire render the use of the whole flight of stairs impossible, and in dealing with staircases it should always be borne in mind that downward escape may be checked by fire and smoke.

For this reason staircases should be carried up to roof level and provided with doors to open outwards, and these doors should be set in deep reveals to eliminate the risk of them being scorched and set on fire by sparks and heat from adjoining conflagrations.

Ways across roof with guard-rails should be formed, and from

the roof step-ladders with flat treads and provided with handrails should lead to the adjoining premises on either side or to staircases giving easy access to ground in detached structures.

4. The installation of apparatus to deal with outbreaks of fire is a necessity in every industrial building and may take various forms, but in most cases a sprinkler system will be found most efficient.

Where this is used a discount of from 25 to 50 per cent. is allowed off the premiums by the insurance companies if the system is carried out in accordance with their official rules.

Lines of horizontal distributing pipes are fixed at intervals of approximately 8 to 12 ft. along the ceiling of each room, and are connected with large vertical rising pipes supplied from the public water main, or any source that will keep the water in the pipes under constant pressure.

To each of the lines of distributing pipes and from approximately 8 to 12 ft. apart the automatic sprinklers are attached. Should a fire break out in any part of the protected building, the heat at once rises to the ceiling, where the temperature is very soon raised sufficiently to melt the solder which holds the valve in position, and this being released, water is discharged over the fire below.

To provide the necessary water for the system a tank must be placed at such an elevation that its base will be 15 ft. above the highest sprinkler of the system which it supplies, in which case it must have a capacity of 7500 gallons. If, however, the base of the tank be 20 ft. or more above the highest sprinkler a capacity of 5000 gallons will be sufficient, but for extensive buildings it is recommended that the tank should be of 10,000 gallons or more.

The tanks are required to be covered in and preferably are enclosed in towers. They are to be kept constantly filled with clean water and provision must be made to prevent the water from freezing.

If it is not convenient to use such a tank, the system may be worked by pumps which must be automatically self-starting.

A modification of the ordinary sprinkler is the "drencher" sprinkler. This is an open sprinkler or valve placed on an empty pipe, the water supply being controlled by a valve which is opened on an outbreak of fire. The object of this type of sprinkler is to form a sheet or wall of water to prevent the flames from passing from one building to another either through a door or windows, and can be used to protect the whole frontage of any building in danger from a fire raging in its neighbourhood.

Hydrants, where necessary, should always be fixed near stairs

and in positions of easy access, and should be inspected at regular intervals. One or more lengths of hose similar to that used by the local fire brigade, together with nozzle, should be kept in a case near hydrant and should never be used except for purposes of fire protection.

Where sprinklers are not used the provision of fire buckets and chemical fire extinguishers is a necessity, and these should always be placed in such a position that they may be reached by anyone in the building without the help of steps or ladders.

Owing to the trade carried on in some buildings, sand is sometimes more useful than water, and in such cases a large bin or tank with outlets from which buckets may be filled should be provided in addition to the sand pails that should always be kept filled.

5. Periodic testing of all gas and electric systems should be made at least every three months, and no tampering with fittings should be allowed. Where steam pipes pass through wood partitions a clear space should be left between pipe and wood, and if this is impossible the opening left filled with asbestos.

6. Fire drill should be practised in all works, and at stated intervals the workers should use the alternative means of escape.

Crowbars and necessary tools for localizing an outbreak should be provided near hydrants, and movable boxes for the reception of oily rags, waste paper, etc., provided.

A general fire alarm system is necessary in all large works and may be carried out by bells, whistles, or gongs.

Where sprinklers are installed the latter can be coupled up with the flow-pipe from tank, so that as soon as an outbreak occurs and water begins to flow the gong is automatically sounded.

7. Lightning conductors should be fixed to all buildings, and where a large area is covered, several may be required.

It is generally assumed that a lightning conductor will safeguard everything within a cone of 60°, and Fig. 45 shows a building fully protected.

Brick and stone is stronger in withstanding electrostatic stresses than metal, and for this reason reinforced concrete buildings must be amply protected, and every means taken to prevent leakages into the construction. The provision of several conductors will not, as is sometimes supposed, lead to a building being struck, but will, on the contrary, prevent flashes occurring at the several points, which serve as leaks to the electric charge, and so greatly reduce its power.

Copper tape makes the best form of conductor, and all joints in

it should be strong and with good electrical conduction. Where several points occur on a roof they may be connected to a main conductor leading to the earth plate, which should be at least 6 ft. below surface. An earth plate 3 ft. square will generally be sufficient in moist earth, but where ground is dry its size should be much greater.

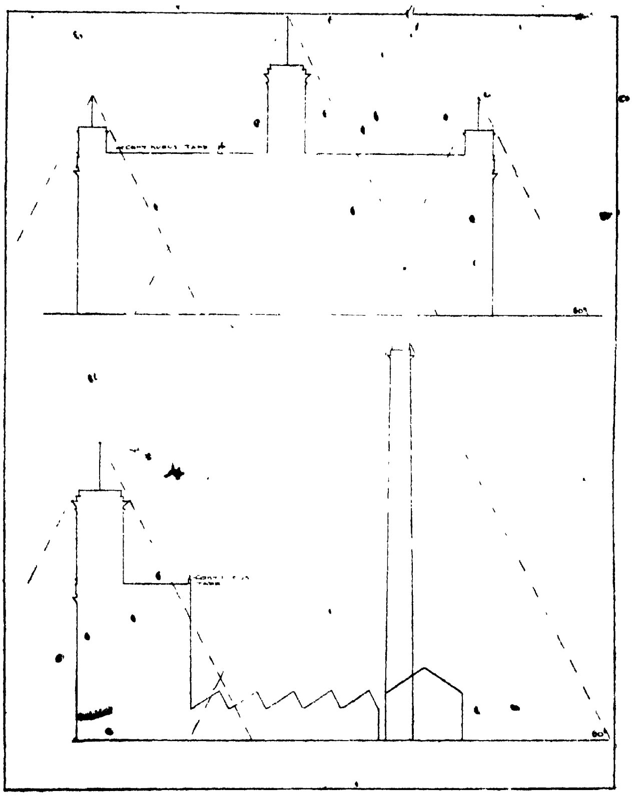


FIG. 45.—Building protected against lightning.

Chimney shafts, especially where of reinforced concrete, should be provided with double conductors, one on either side, and the top ends should be riveted and soldered to a continuous band around the top of the cap, which should be fitted with from 4 to 8 long single-pointed copper rods.

On tall chimneys a test clamp should be fixed near ground in one

of the tapes so that no ladders are required when testing takes place, and as all conductor systems are liable to get out of order, they should be inspected and tested at intervals.

The risk of fire is ever present on account of the carelessness of workers, but suggestions as to rules within the factory would be out of place in this volume. As the most stringent rules, however, cannot eliminate the human element, every building should be so designed that when fires occur no person can possibly be trapped.

CHAPTER XIII.

THE ARCHITECTURAL CHARACTER OF THE BUILDING AND THE PREPARATION OF THE DRAWINGS.

THE opinion is often expressed that an architect is not required for the design of factory and industrial buildings, and that the simplicity of their lines leaves no chance of any character being impressed upon them.

Such statements seem to spring from a mistaken notion that architectural character is something that can be given to a building by firstly, sacrificing certain uses for the purpose of gaining effects, and secondly, by adding extraneous ornament in the same manner that sugar decorations are added to a cake, and both ideas are erroneous. Rightly understood, architectural character in any building is the expression of its construction, and in a modern steel framed or reinforced concrete building, where the weights of each part are carried direct to stancheons or piers placed at regular intervals, the architect may, by the exercise of thought and by the expenditure of but a trifling sum, give an impression of power and dignity that can only otherwise be obtained in large public buildings.

The monotony of the average Victorian-age factory is apparent to every one, and it must be admitted that when money was allowed for the elevations, ornament and details that would have been just as much in place on a block of flats or on a small public building were often wrongly employed.

The tendency, however, now displayed by both American and English architects of concentrating on the structural lines, and which is exemplified in many of the illustrations in this volume, should prove that architectural effect may be gained without any sacrifice of the uses of the structure.

Where a sprinkler system is installed the height and enclosure necessitated by the tank will, if properly dealt with, form a fitting central feature of the whole group, and careful placing and detailing of the canteen and office blocks may lead to a mass grouping that is impossible with ordinary city buildings.

In placing the buildings on the site the desirability of setting the whole structure back from the road and forming a grass lawn or flower beds in front is worthy of consideration if land can be spared

FIG. 46.—Main entrance to offices for Bovril, Ltd., Old Street, E.C. (Lanchester & Rickards, F.R.R.I.B.A., Architects.)

for such purpose. Not only will less dust drift into factory from the passing traffic on main road, but the appearance of the building will be improved, and this alone is a great asset from the advertisement point of view.

The effect of approaching and entering a well-grouped and dignified building has also an influence on the workers that tends towards happiness and better production, and although advertisement and

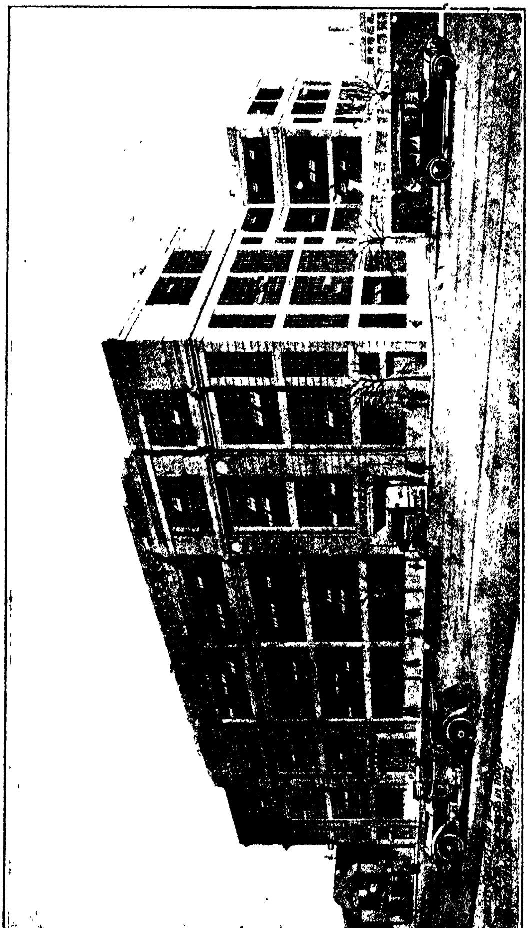


FIG. 47.

psychological effect on workers have been but little considered in this country, they are in America realized to be of great importance.

In the preparation of the working drawings, clearness and accuracy are essential, and as most industrial buildings have to be

rapidly erected, every detail of construction should be settled and drawn out before work is commenced.

Except for the key plans a scale of $\frac{1}{8}$ in. to a foot is usual, but

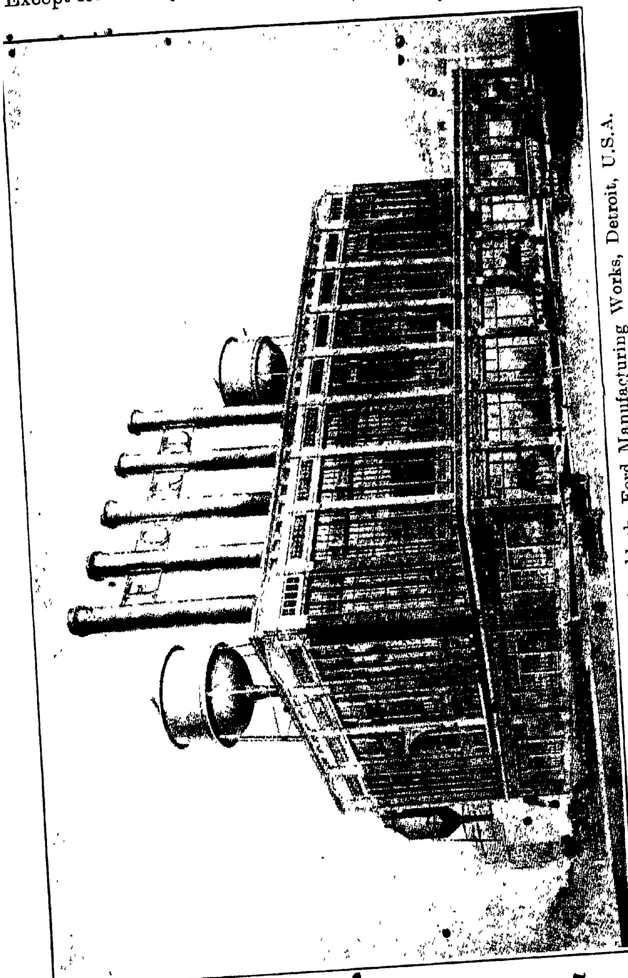


FIG. 47A.—The administrative block, Ford Manufacturing Works, Detroit, U.S.A.

sections through bays and elevations should be drawn to a scale of $\frac{1}{2}$ in. to a foot. This may seem unnecessary, but it will often be found that in drawing out to this scale difficulties that would afterwards arise will be at once solved, and subsequent time and expense saved.

All dimensions should be figured, care being taken that the intermediate dimensions when added tally with the overall ones, and in a good set of drawings the application of the scale should be almost unnecessary.

The use of large scale and isometric sketches of intricate details

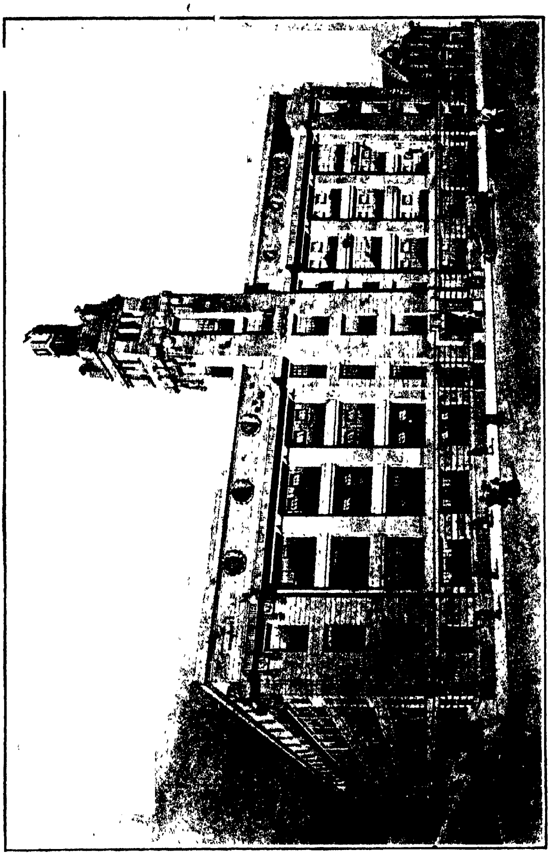


Fig. 48.—Proposed factory. (Wallis Gilbert & Partners, Architects.)

will often be a great help to the foreman, and may save mistakes and delay in the progress of the work, and especially in steel and reinforced concrete work, plans, sections, and elevations of all sides of members and their connections to each other are desirable.

The colouring of drawings tends to make them more easily read, but a greater use of cross hatching of various forms would often save

much time when a number of copies of each drawing are required. In all cases where drawings are coloured the same colour should in-

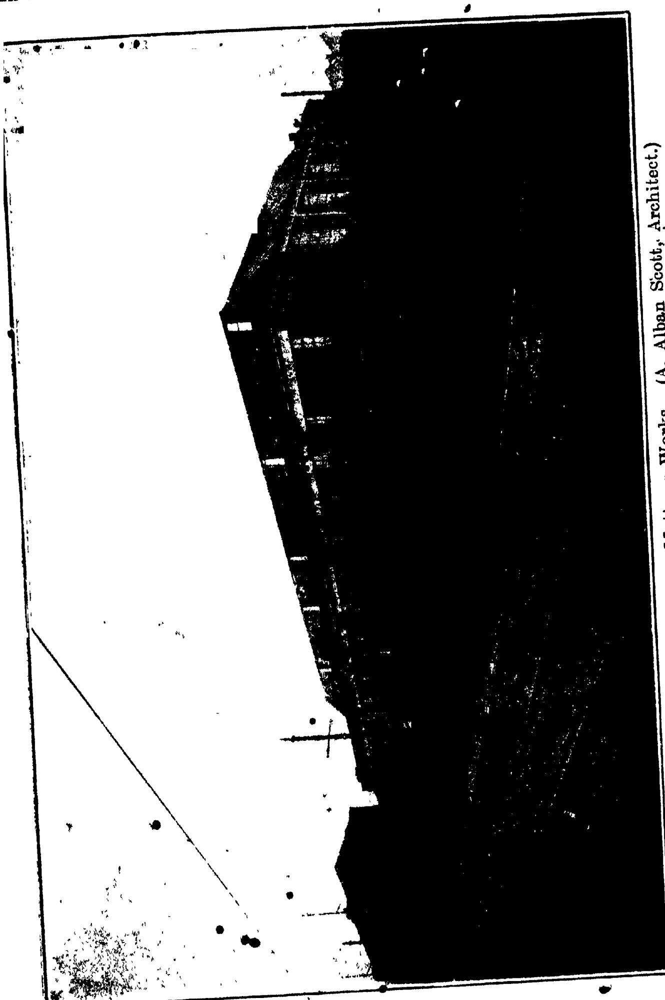


FIG. 49.—Exterior of Vi-Spring Mattress Works. (A. Alban Scott, Architect.)

variably indicate the same material, and a copy of the colour chart supplied to the contractor, who should receive the whole of the drawings required at the commencement of the job.

CHAPTER XIV.

REPRESENTATIVE FACTORY AND INDUSTRIAL BUILDINGS.

The Spirella Company's Works, Letchworth.—This building not only provides for the workrooms and offices of the company, but recreation-rooms, rest-rooms, gymnasium, roof-garden, classrooms, bathrooms, and a large concert hall, with seating accommodation for 1000 persons are provided for the employees.

The structure at present consists of two blocks, and as the business increases it is proposed to add a further block to form a hollow square. The first is 172 ft. long by 55 ft. wide, and is almost entirely devoted to the business of the company. The basement is used for stores, the ground floor as offices, and the first floor and gallery as workrooms, whilst the top floor adjoining the roof-garden is used as rest and recreation-rooms.

The second block is 115 ft. by 55 ft., and the concert hall occupies its top floor.

Fig. 50 shows the exterior of the building, by which it will be seen that it is faced with brickwork with concrete window sills and heads showing on surface. A unique feature of the elevation is the top floor of the end pavilions, which extends out to the face of the projecting bays below. This floor and the enclosing wall are carried on a deep beam supported by reinforced cantilevers projecting from the wall below.

With the exception of the enclosing brick walls, the whole of the structure is of reinforced concrete, of which the most interesting feature is the roof over concert hall. This is roofed with a concrete slab resting on arched beams springing from wall to wall, and these have eight longitudinal stiffening beams 10 ins. by 6 ins. between them. Owing to the large span a depth of 36 ins. was necessary for these arched beams, and to obviate an excessive depth showing in the hall they project above the general roof surface.

The roof itself consists of a 3½ in. slab, and the whole surface, in-

cluding the projecting beams, is finished with asphalt. To take away from the monotony of the long arched roof two reinforced concrete domes have been formed (see Fig. 55).

Another feature worthy of note is the gallery on the first floor of block No. 1, which runs down the middle of the room instead of being

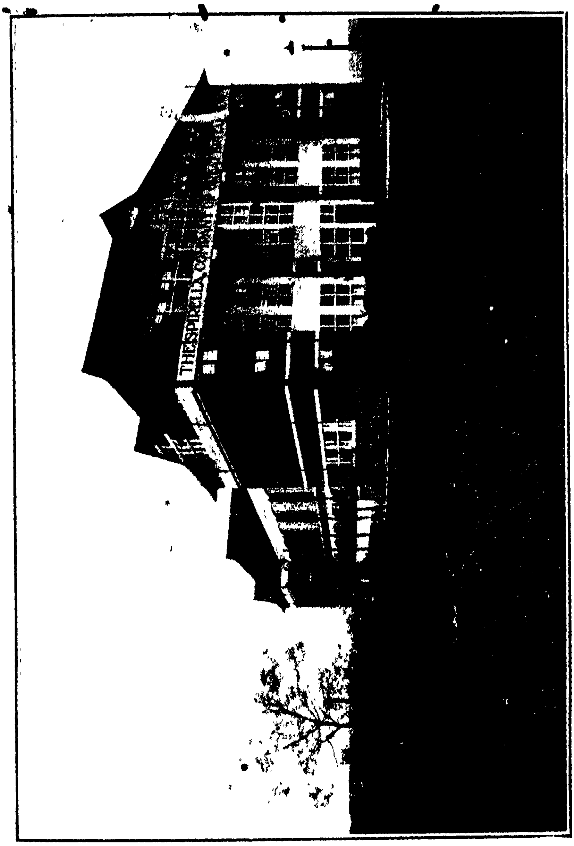


FIG. 50.—The Spirella Co.'s works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architect.)

attached to the outer walls. The use of a central gallery is common in America, and the lighting results gained from its use as compared with the central well not top lighted, justify its extended use in future factories in this country.

The architect for the work was Mr. C. H. Hignett, Lic. R.I.B.A.,

of Letchworth, and the engineers for the reinforcement The Indented Bar and Concrete Co. of London.

Factory, Tottenham Court Road.—This building is noteworthy

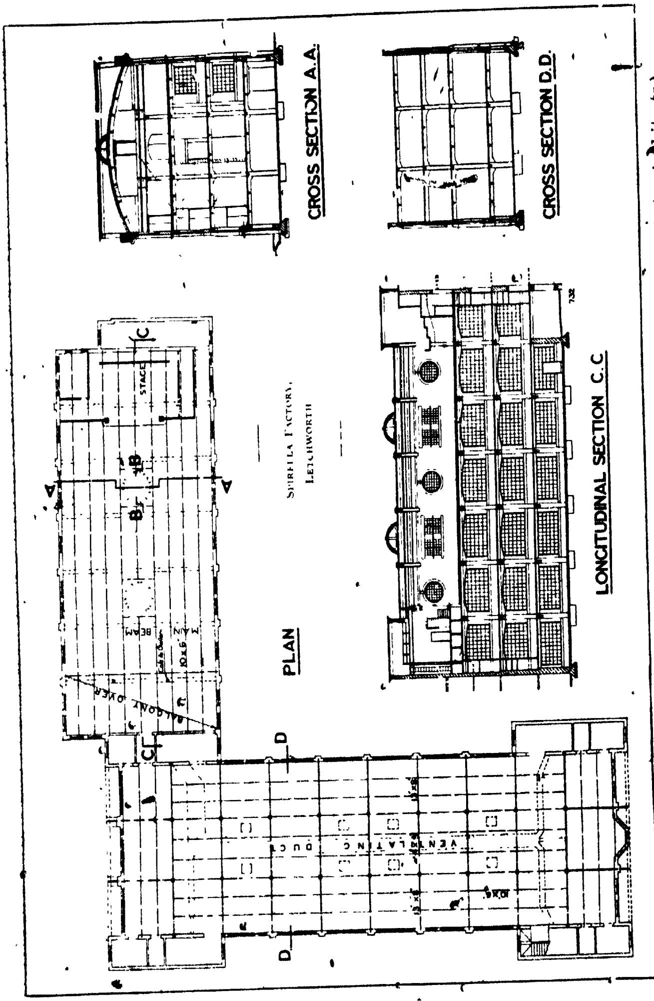


FIG. 51.—The Spirella Co.'s works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architects.)

as an example of a factory building erected in a main street in the heart of London.

At present only a portion of the complete structure is finished,

but Fig. 56 shows the proposed completed elevation. The building contains both the workshops and the offices for the company, and possesses several interesting features.

Fresh air to the rooms is admitted through gratings or cast-iron pierced bosses formed in the panels below windows to a duct which

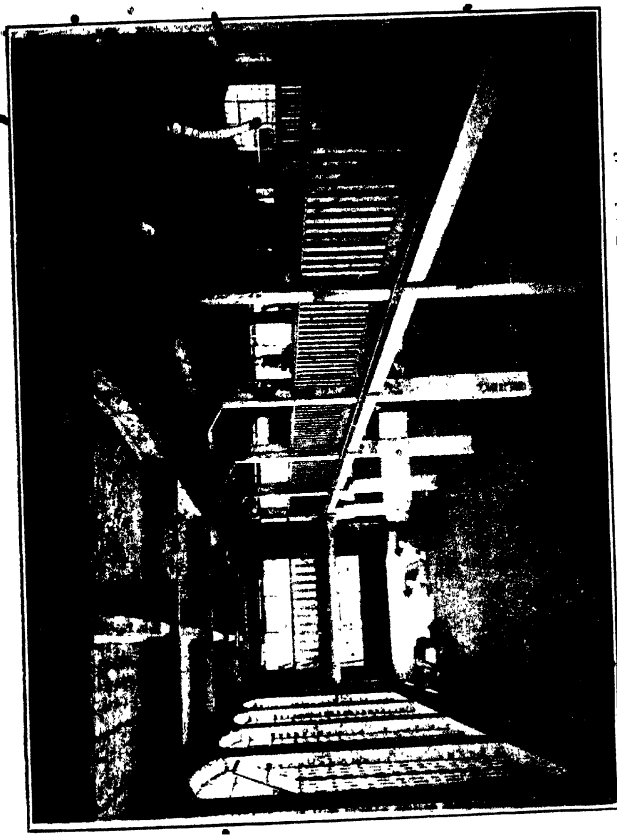


FIG. 52.—The gallery, the Spirella Co.'s works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architect.)

runs from pier to pier. Under each window a radiator or coil of pipes is placed, and the heat passing through a thin slab warms the air, whilst provision is also made for fixing hot-water pipes in the duct should greater temperatures be required. The inlets from this duct to the rooms are at ceiling level and are controlled by a simple mechanism to allow greater or lesser amount of air to enter rooms.

Throughout the building the air inlet is at ceiling level and outlet at or near floor, and thus no possibility exists of workers inhaling dust given off by machines. Moreover, to prevent annoyance of sheets of cold air from the windows falling on the workers at the

FIG. 53.—The gallery, the Spirella Co.'s works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architect.)

benches, an arrangement of hot pipes keeps a layer of warmed air between the glass and the worker.

In order to eliminate the waste of furnace gases and heat that would otherwise pass away in chimney an economiser system of heating is installed which heats the whole of the basement.

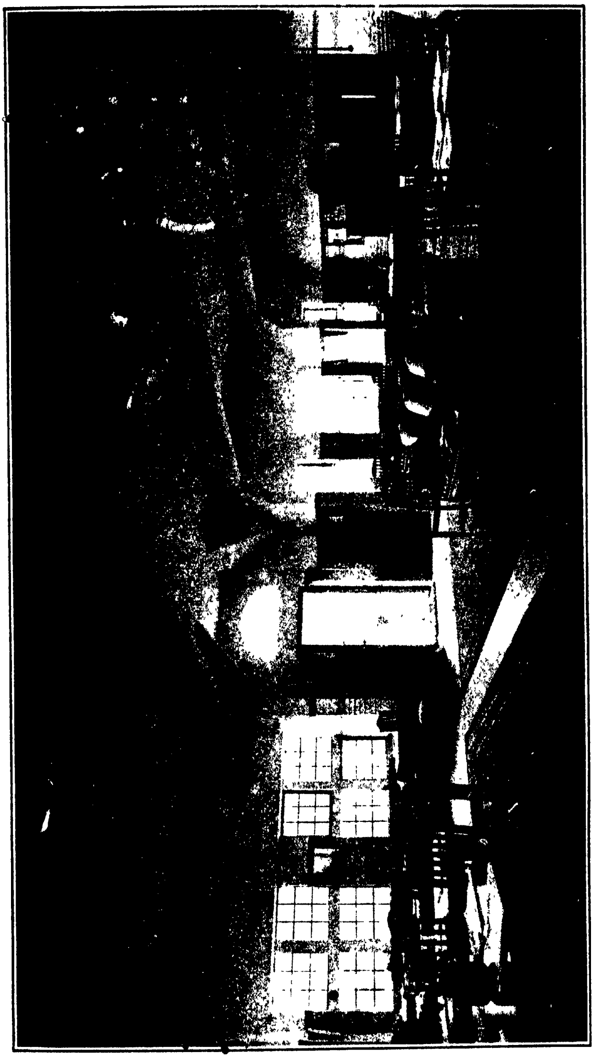


FIG. 54.—The girls' rest-room, the Spirella works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architect.)

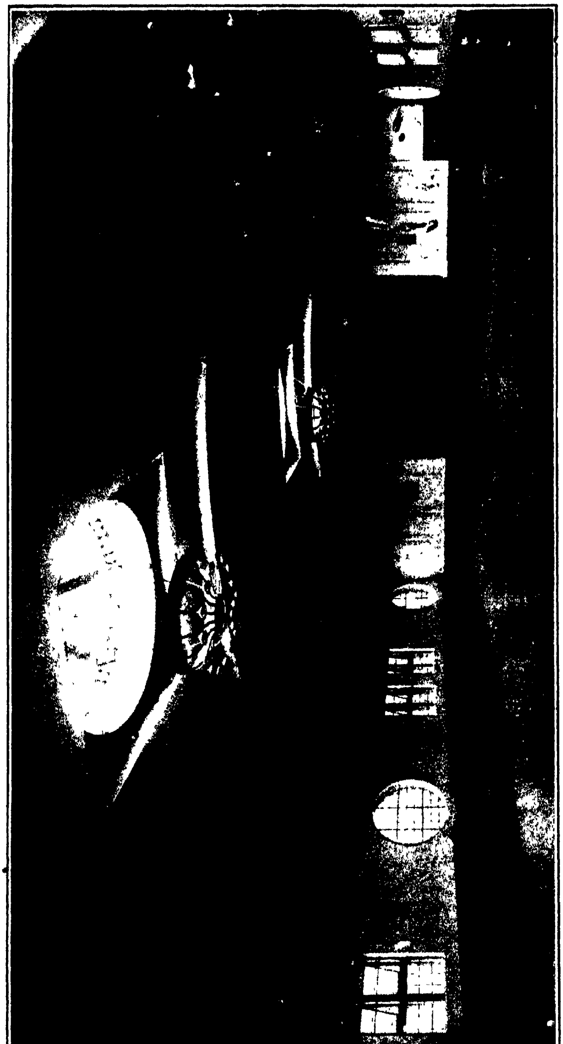


FIG. 55.—The concert hall, the Spirella Co.'s works, Letchworth. (C. H. Hignett, Lic. R.I.B.A., Architect.)

Change of air to all rooms is effected by forming louvres in the bottom of all doors to staircase, and on the roof above the stairs a large exhaust fan chamber is formed.

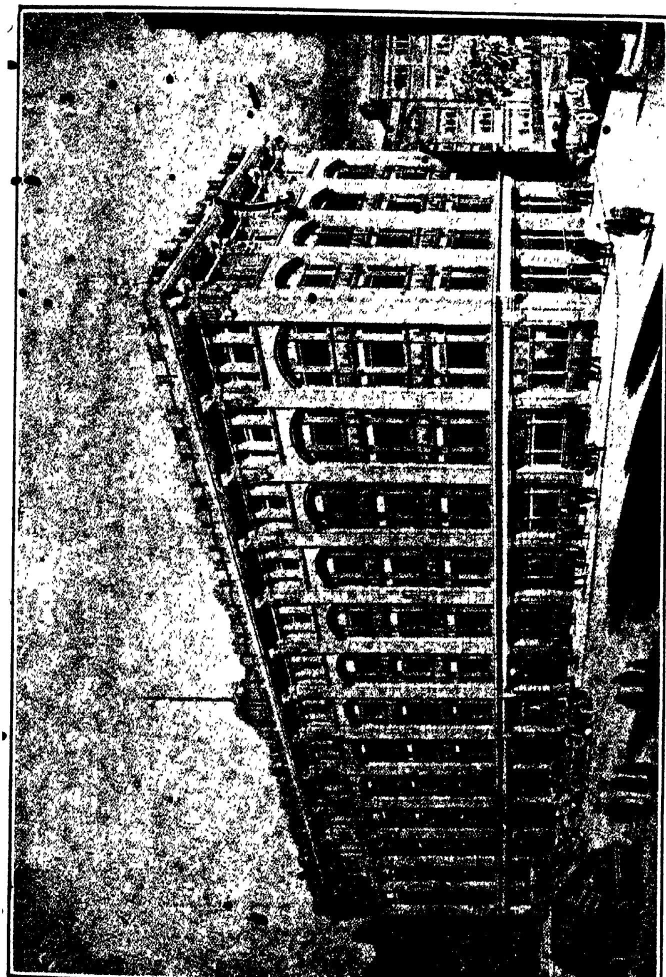


FIG. 56.—Factory, Tottenham Court Road. (Hobden & Porri, Architects.)

Ample lighting is provided throughout, but to give a maximum of daylight to the basement a bulkhead is formed on the ground floor and continuous pavement lights constructed in footway, and in order

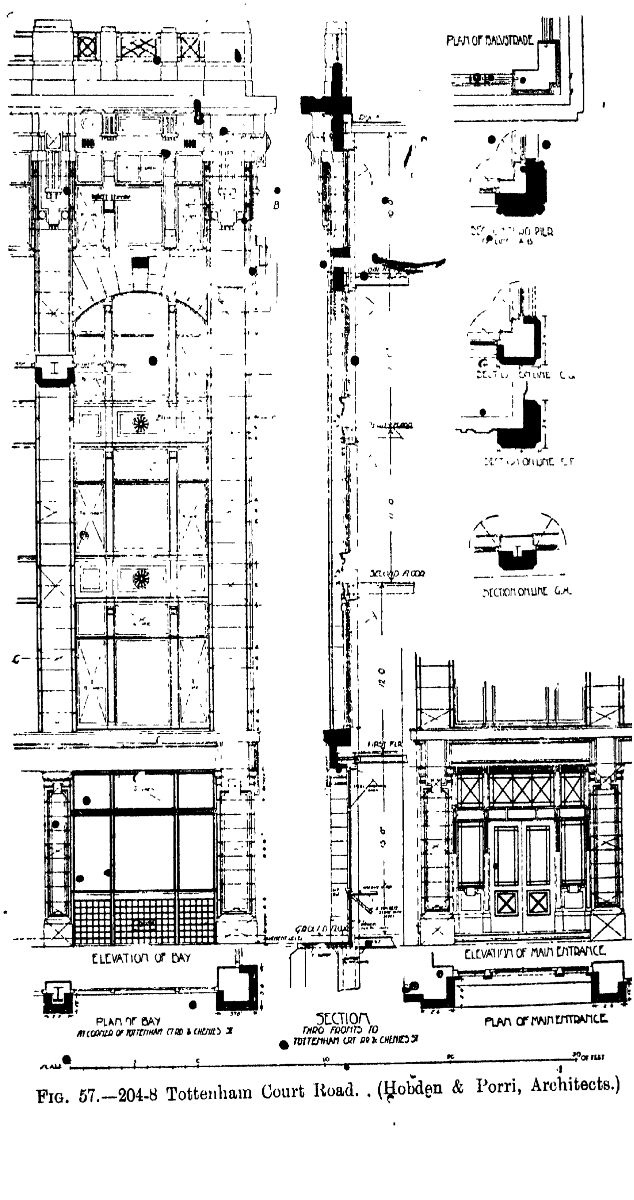


FIG. 57.—204-8 Tottenham Court Road. (Hobden & Porri, Architects.)

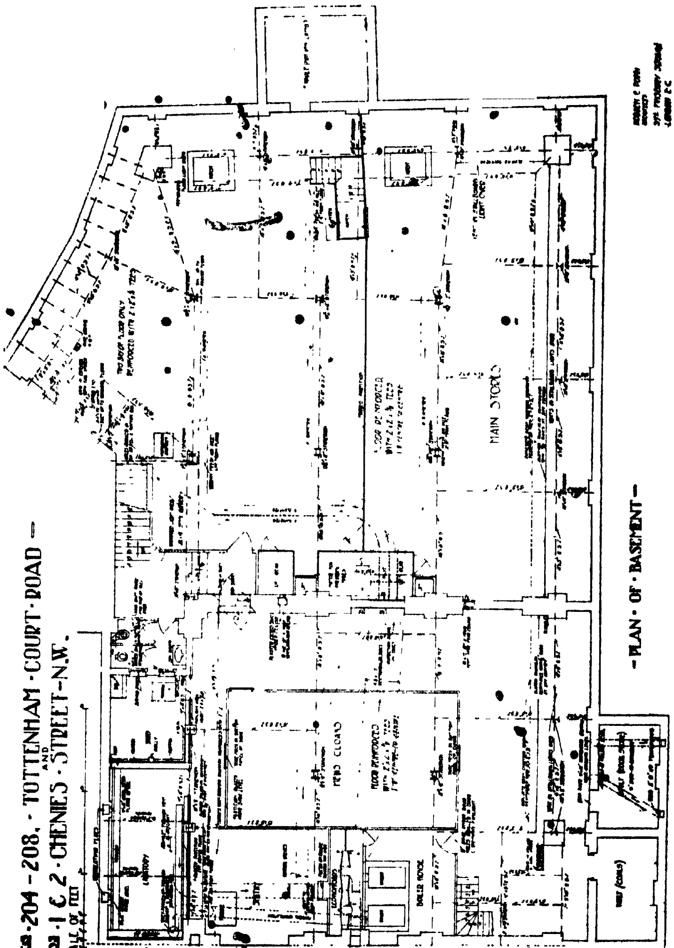
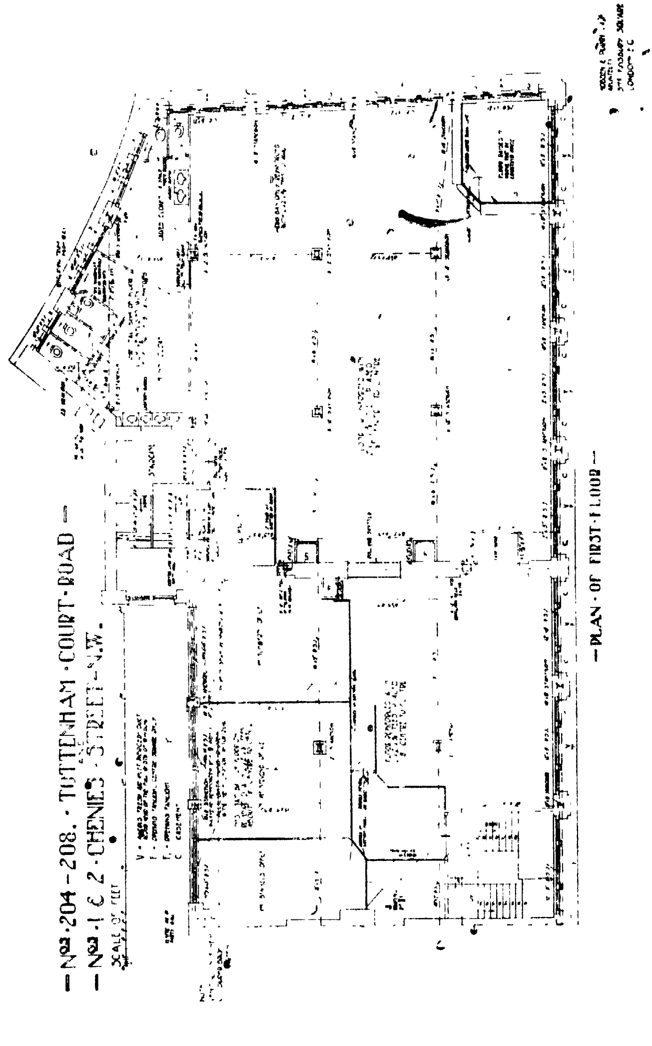

— Nos. 204 - 208. · TOTTENHAM · COURT · ROAD —
AND
— Nos. 1 & 2 · CHENIES · STREET · N.W.
SCALE OF FEET
MAIN STORES
— PLAN · OF · BASEMENT —

FIG. 58.



—Nos. 204 - 208. · TOTTENHAM · COURT · ROAD —
—Nos. 1 & 2 · CHENIES · STREET · N.W.
SCALE OF FEET
—PLAN · OF FIRST · FLOOR —

to obviate the necessity of a R.S.J. at the pavement level, the inner edge of the pavement lights is supported on an angle iron suspended from a 6 in. × 5 in. R.S.J. fixed behind stallboard.

The building is of steel-framed construction throughout, with

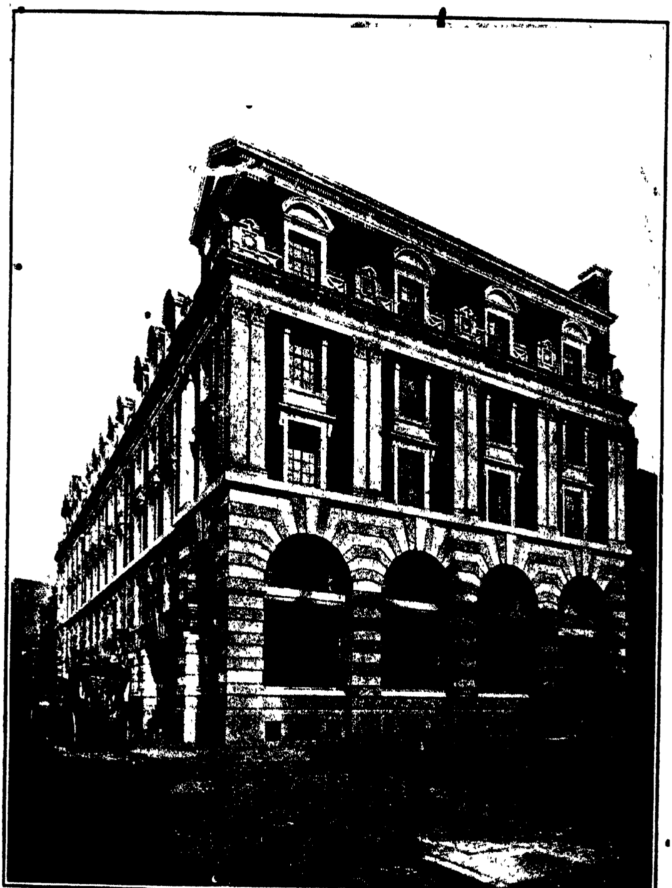


FIG. 60.—Warehouse, Stamford Street, S.E. (A. Sykes, F.R.I.B.A., Architect.)

stanchions in all piers except those at ends of party walls and at corners of streets. The ground, first, and second floors are of concrete reinforced with 2 in. × 2 in. × ? Ts spaced 20 ins. apart, whilst the remainder of floors and roofs have reinforcement of Monlithcrete joists.

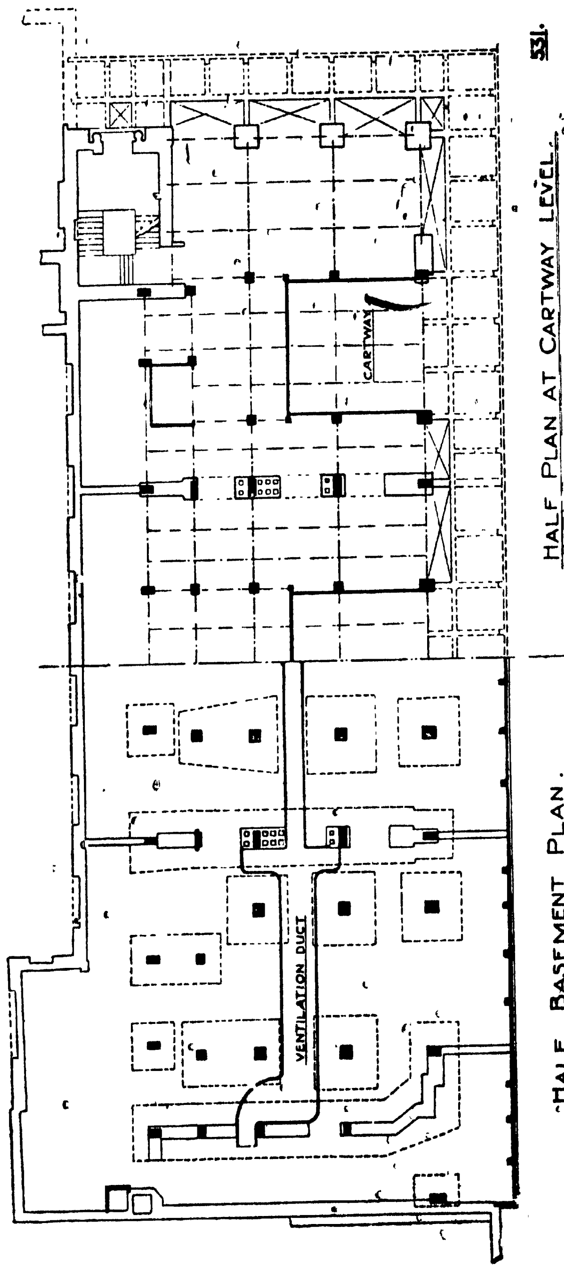
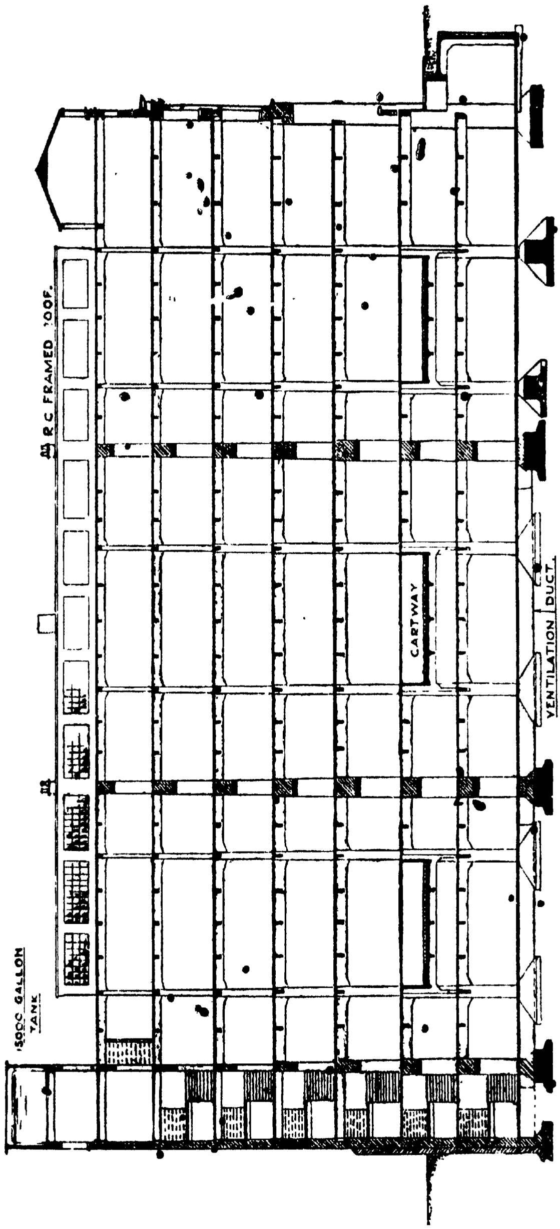


FIG. 61.—Warehouse, Stamford Street, S.E. (A. Sykes, F.R.I.B.A., Architect.)



LONGITUDINAL SECTION.

FIG. 62.—Warehouse, Stamford Street, S.E. (A. Sykes, F.R.I.B.A., Architect.)

The elevations are of Portland stone, the panels between windows being cast iron.

The architects for the buildings were Messrs. Hobden & Porri, of 37A Finsbury Square, E.C.

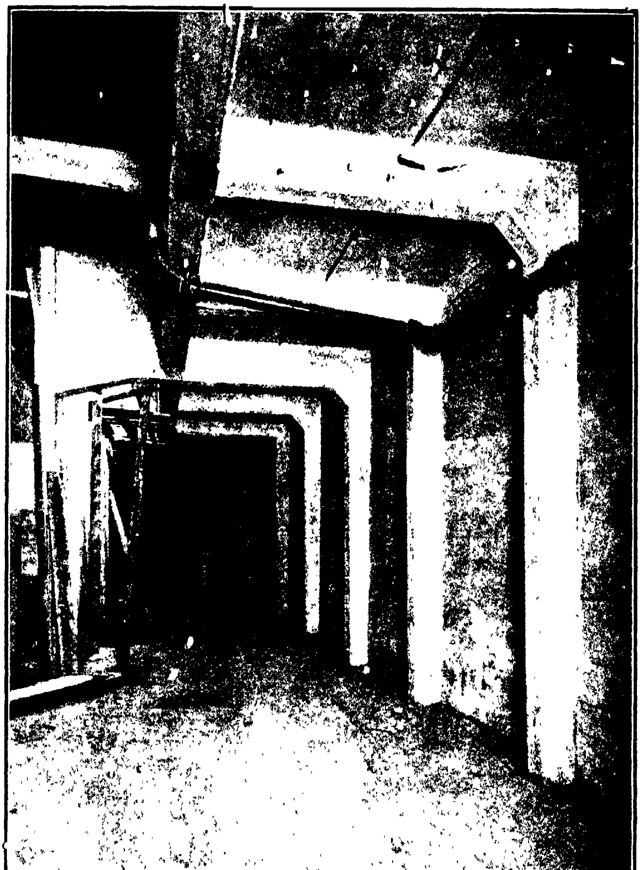


FIG. 63.—Vault under pavement, warehouse, Stamford Street, S.E. (A. Sykes, F.R.I.B.A., Architect.)

Warehouse, Stamford Street.—This building was erected for Mr. J. Sainsbury for the storage of provisions, and except for the outer walls, which are of brick and stone, is of reinforced concrete construction throughout.

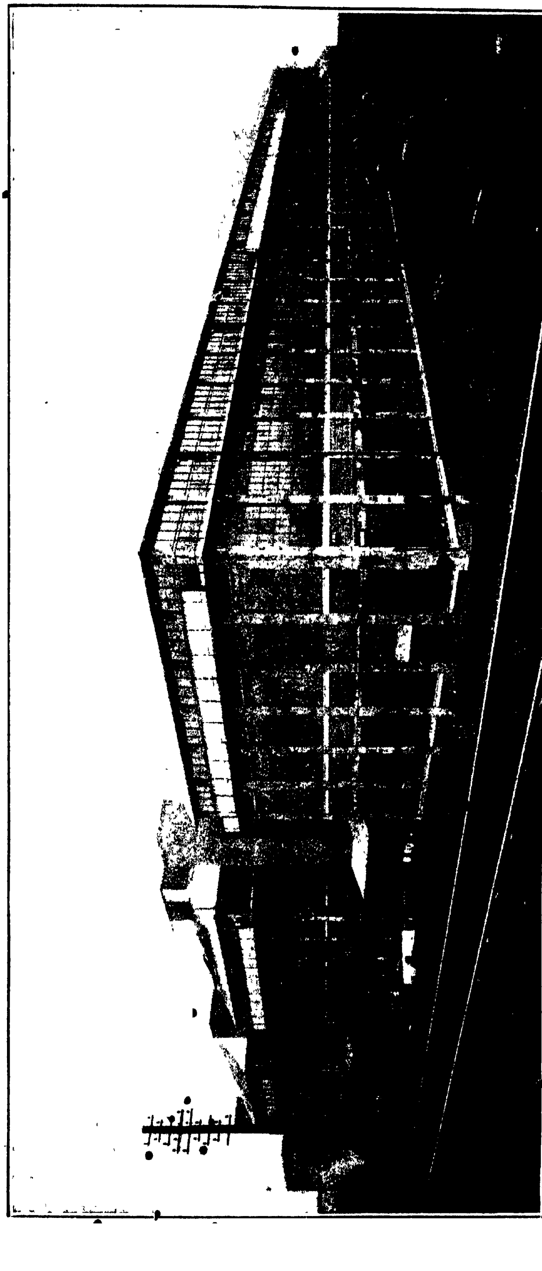


FIG. 64.—Factory at Birmingham. (Buckland Haywood & Farmer, Architects.)

Its position close to the river Thames necessitated great care in the design of the foundations, and as far as possible the party walls and piers were carried on continuous inverted T beams.

The building consists of basement with six floors over, and pavilions containing dining-rooms, lift machinery, and a reinforced concrete

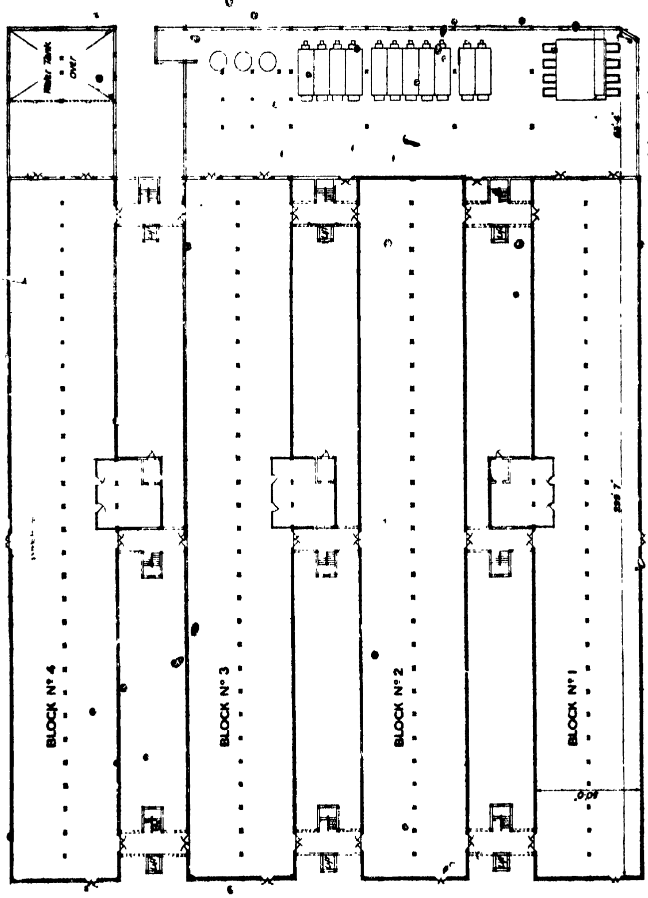


FIG. 65.—Factory at Birmingham. (Buckland, Haywood & Farmer, Architects.)

tank for 15,000 gallons of water are formed at ends of structure above general roof level.

The basement is about 187 ft. long by 75 ft. wide, and the two walls abutting on streets are of reinforced concrete varying from 6 to 8 ins. thick and stiffened by 10 × 10 vertical beams tied to basement floor

and to a horizontal beam at top. These horizontal beams also support the footway and the pavement lights.

The whole building was tanked with asphalt, and to save space a $4\frac{1}{2}$ in. wall was built in sections next earth, timbered as soon as complete, and the asphalt applied to wall immediately before concrete was filled in.

As will be seen from section, Fig. 62, the ground floor is raised about 4 ft. above pavement, and three large loading cartways are

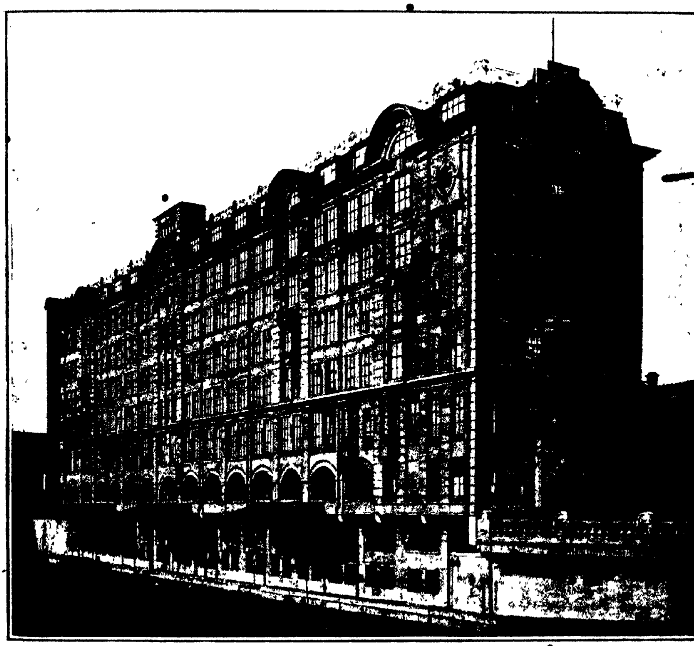


FIG. 66.—Messrs. Ralli Bros.' warehouse, Manchester. (W. & G. Higginbottom, Architects.)

constructed from street into the building, so that floors of lorries are at about the level of ground floor of building. These cartway docks are capable of carrying the heaviest type of loaded lorries and consist of a 5 in. slab resting on main and secondary beams, the slab being finished with 4 in. granite cubes.

The lift wells are enclosed with slabs of concrete 3 ins. thick, reinforced both horizontally and vertically.

Except for the necessary cross walls, which are fitted with double

fire-resisting doors, the building is designed for open floors to carry a load of 4 cwt. per sup. ft.

Over the top floor a reinforced concrete lantern runs almost the whole length of building, and is shown in Fig. 62

The structure was tested to $1\frac{1}{2}$ times the working load on three

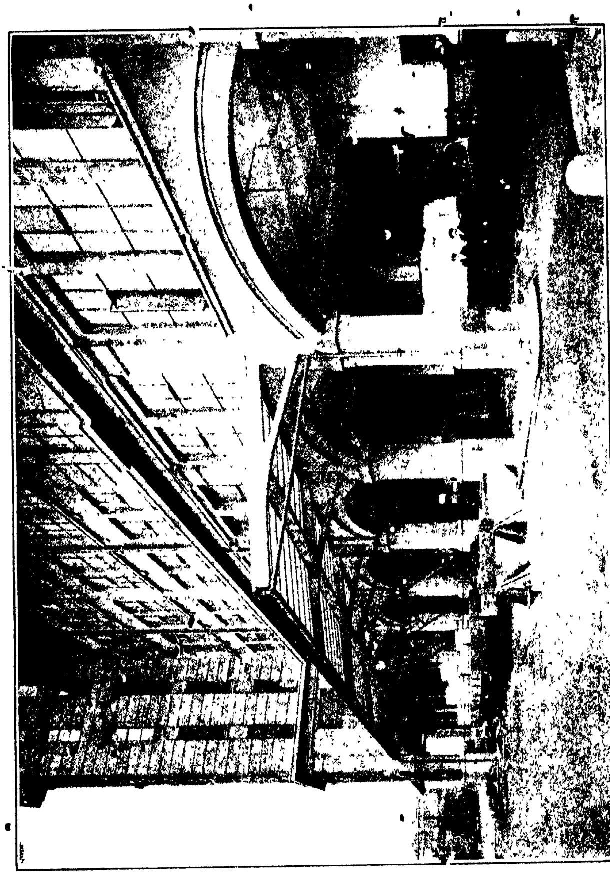


FIG. 67.—Messrs. Ralli Bros., Manchester. (W. & G. Higginbottom, Architects.)

floors simultaneously, and the maximum deflection of main beams was but $\frac{1}{5400}$ of span. The architect for the building was Mr. A. Sykes, of Finsbury Pavement, E.C.

Factory at Birmingham.—This building, which is one of the largest factories in the Midlands, consists of four blocks, each 299 ft.

7 ins. long by 50 ft. wide (inside dimensions). Cleaning rooms 22 ft. by 29 ft. project from blocks 1, 3, and 4 into the areas between the various blocks. These areas are 32 ft. wide, and across each of them at the first and second floor levels three bridges are formed, thus giving access from one block to another. Staircases and lifts are constructed in the areas adjoining the bridges, and on either side of them, and the possibility of fire spreading from one floor to another or from one block to another is practically eliminated. At one end

FIG. 68.—Messrs. Ralli Bros.' warehouse, Manchester. (W. & G. Higginbottom, Architects.)

of the factory are two one-story buildings, containing muffle furnaces, boilers, and generators. The first, 63 ft. 4 ins. wide, extends the full width of blocks 1, 2, and 3, and the areas between them, whilst the second is an extension of block 4, measures 50 ft. by 63 ft. 4 ins., and carries on its roof a water tank with a capacity of 35,000 gallons of water.

The construction throughout is of reinforced concrete, and the building is designed on a unit plan with maximum daylight lighting.

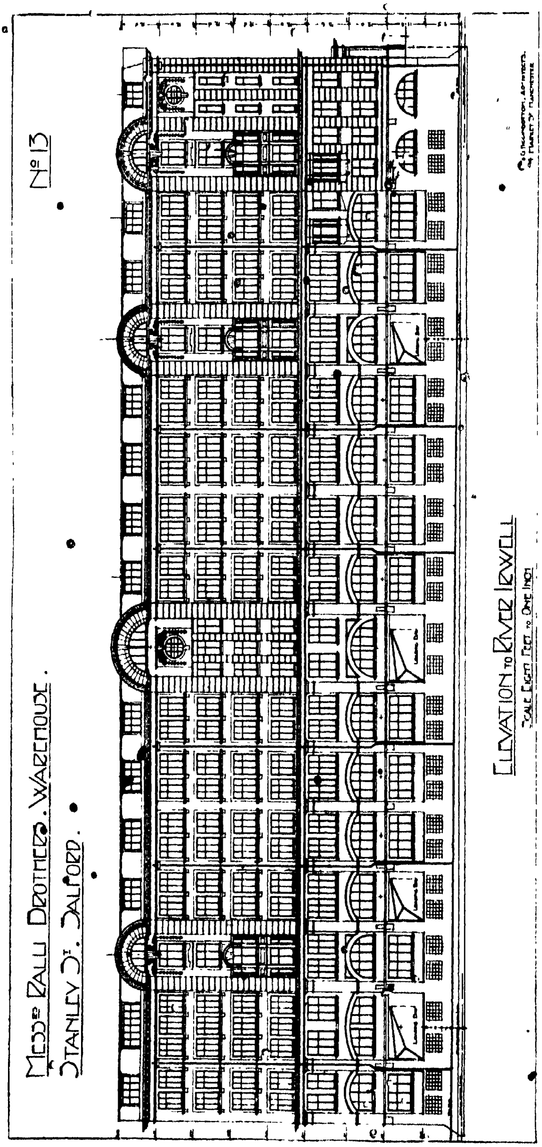
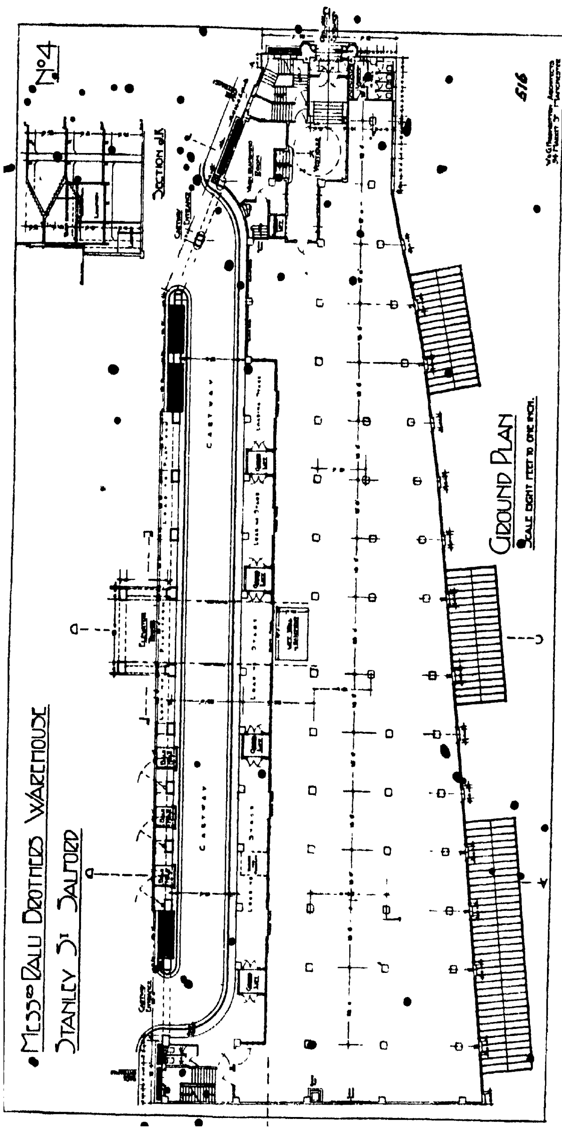

Messrs Ball Brothers. Warehouse.
Stanley St. Salford.
No 13
Elevation to River Irwell
Scale Eight Feet to One Inch

Fig. 69.



No 4
Messrs Dalli Brothers Warehouse
Stanley St Salford
Ground Plan
Scale eight feet to one inch
516

Fig. 70.

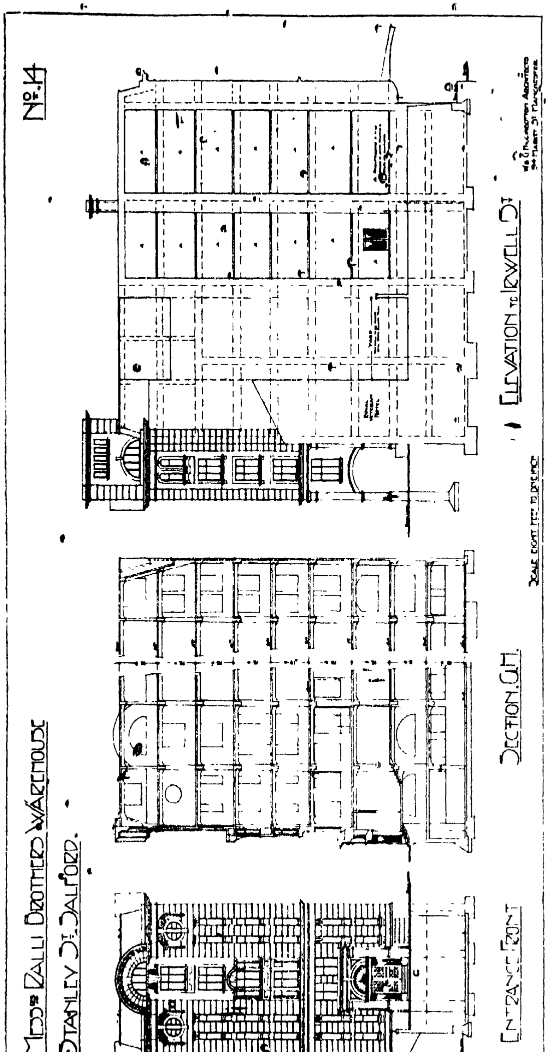

No. 14
Mess^rs Ralli Brothers Warehouse
Stanley St. Salford.
Elevation to Irwell St.
Section G.H.
Entrance Front

Fig. 71.

The site was mostly made-up ground and a good foundation was only found at considerable depth. The foundations are stepped in places and consist of reinforced inverted 5 beams, which run the

FIG. 72.—The Pall Mall Depository, North Kensington. (W. G. Hunt, F.R.I.B.A., Architect.)

whole length of building both under central and wall piers. These piers, spaced at 10 ft. centres, are tied together at roof by beam running around blocks. The ground floor consists of a reinforced concrete slab entirely independent of walls and columns, and should

the made-up ground subside, the slab would adjust itself to the new level.

The first floor slab rests on secondary beams at 5 ft. centres and is 4 ins. thick. The roof trusses are of steel, 50 ft. span, and

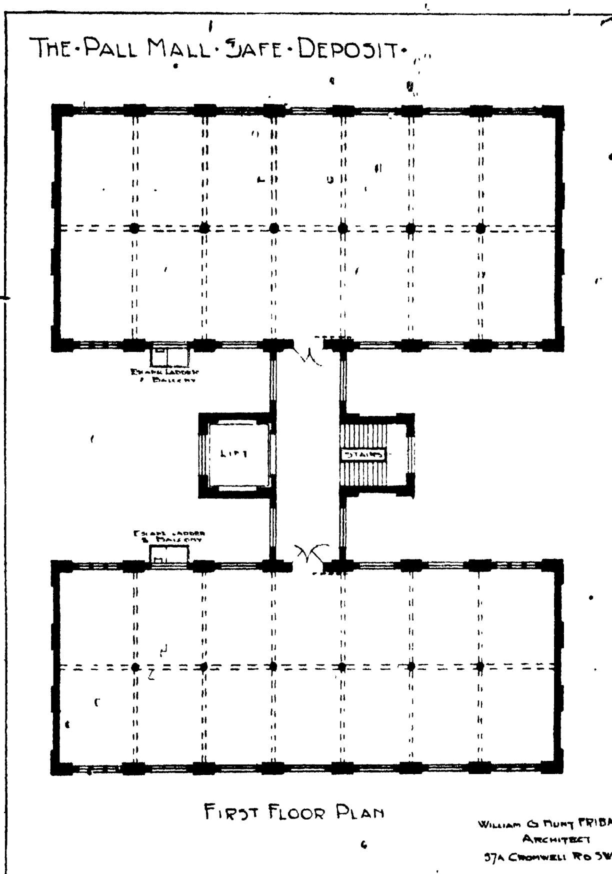


FIG. 73.

supports the light asbestos roofing slates with which the building is covered.

The staircase and lift-wells are encased by 14 in. brick walls carried by beams at ground floor level. These beams rest on columns

on separate foundations carried down to the clay, and the columns next bridges are carried up to the roof and support reinforced concrete tanks over the second floor in two cases. These tanks are constructed to hold 1500 gallons of water.

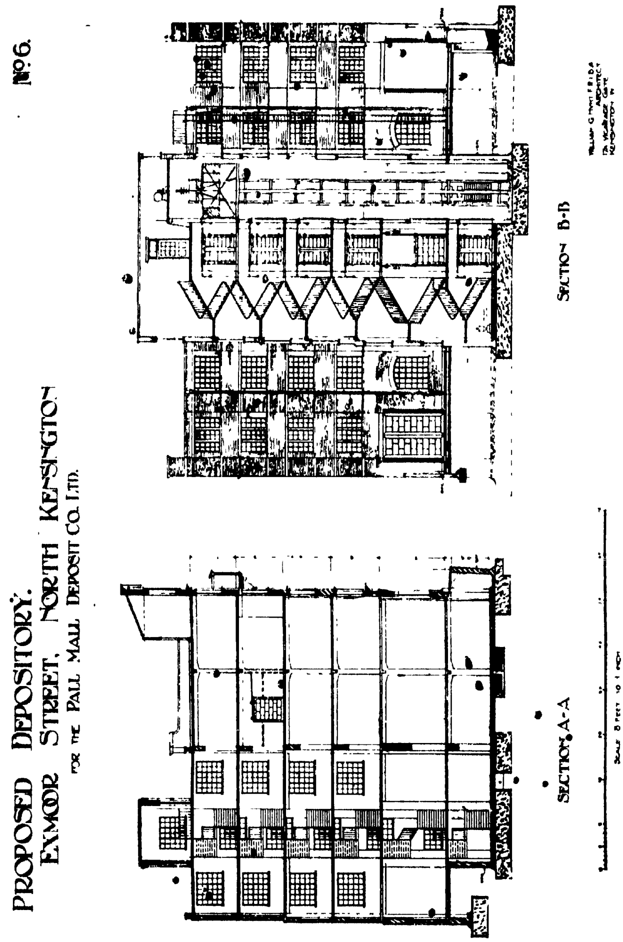


FIG. 74.

The bridges between stairs and lifts consist of a 4 in. slab of 6 ft. span, supported on secondary beams resting on the main beams carried on the columns. Sinkings 12 ins. deep are formed in the

floors of the bridges for weighing machines, and thus all work coming from the factory can be weighed before entering the lifts.

The architects for the works were Messrs. Buckland, Haywood,

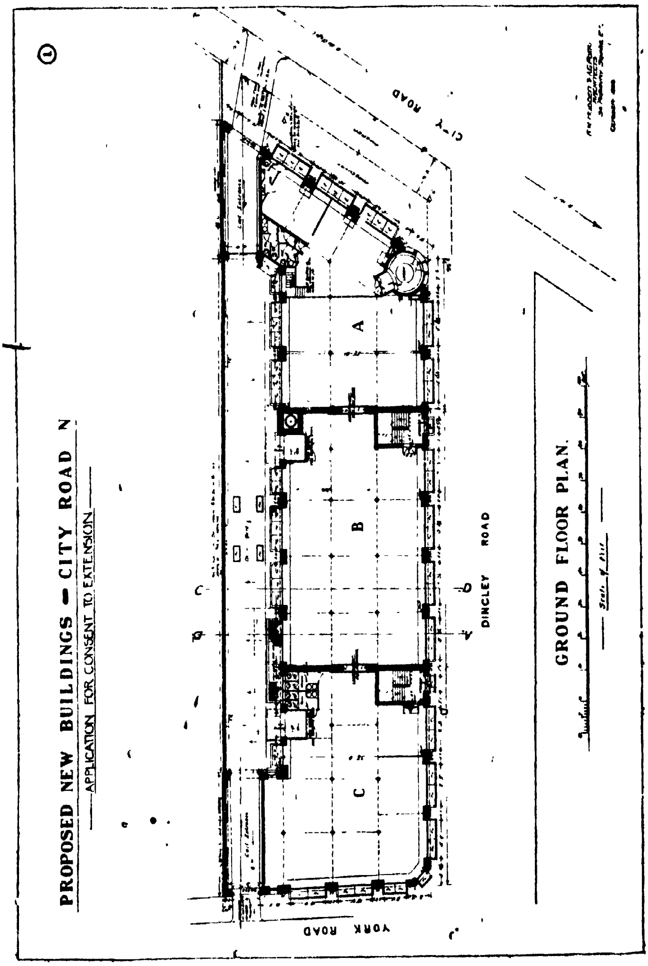


FIG. 75.

& Farmer of Birmingham, and The Indented Bar Co. of Westminster were responsible for the details of the reinforcement.

Warehouse, Manchester. — This building was erected for Messrs. Ralli Bros. for the storage of cotton, and is noticeable on

account of the whole of the structural work in it being of reinforced concrete.

No extraneous materials have been introduced for effect, and ex-

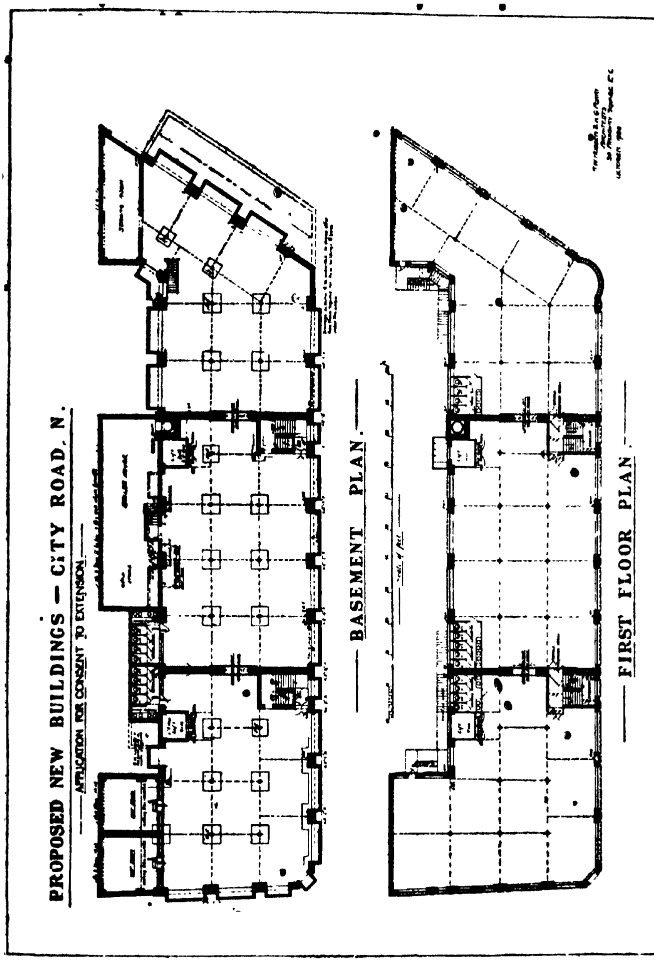


FIG. 76.

cept for the curved pediments and cornices every line is the outcome of the material employed to the structural necessities of the building. The external walls are left as they appeared when the timbering was removed, and with the exception of part of entrance front and a

brick party wall the structure is entirely of concrete and steel. By forming the walls of this material a great saving of space was

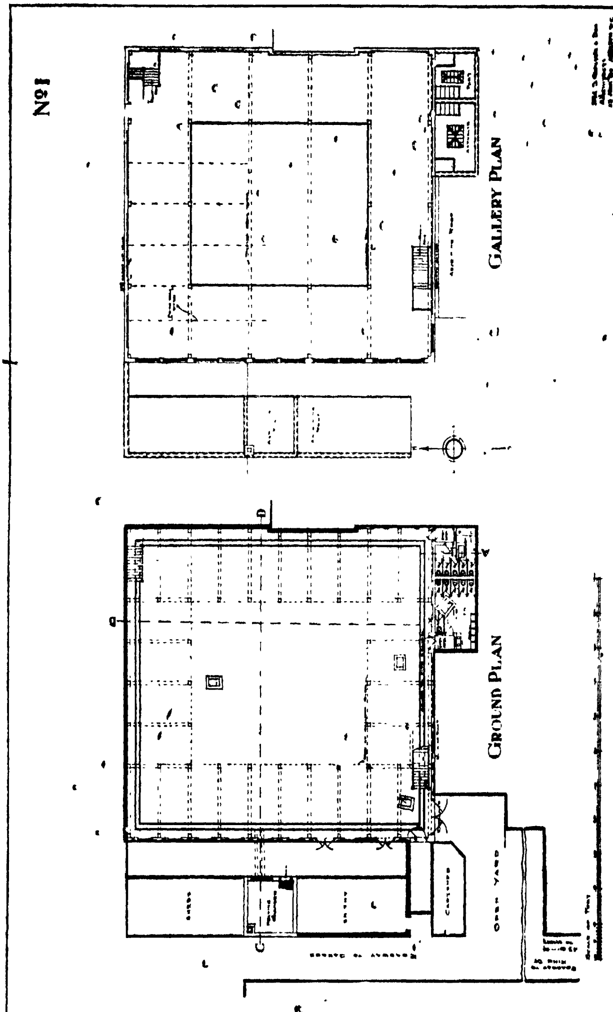


FIG. 77.—A timber-framed factory.

effected; for the external walls are but 7 ins. thick up to cornice and 5 ins. above that point. Where rustication is introduced, however, the thickness is 11 ins.

The plan (Fig. 70) and section (Fig. 71) show the building to be roughly 300 ft. long by 100 ft. wide, with nine floors and a flat roof.

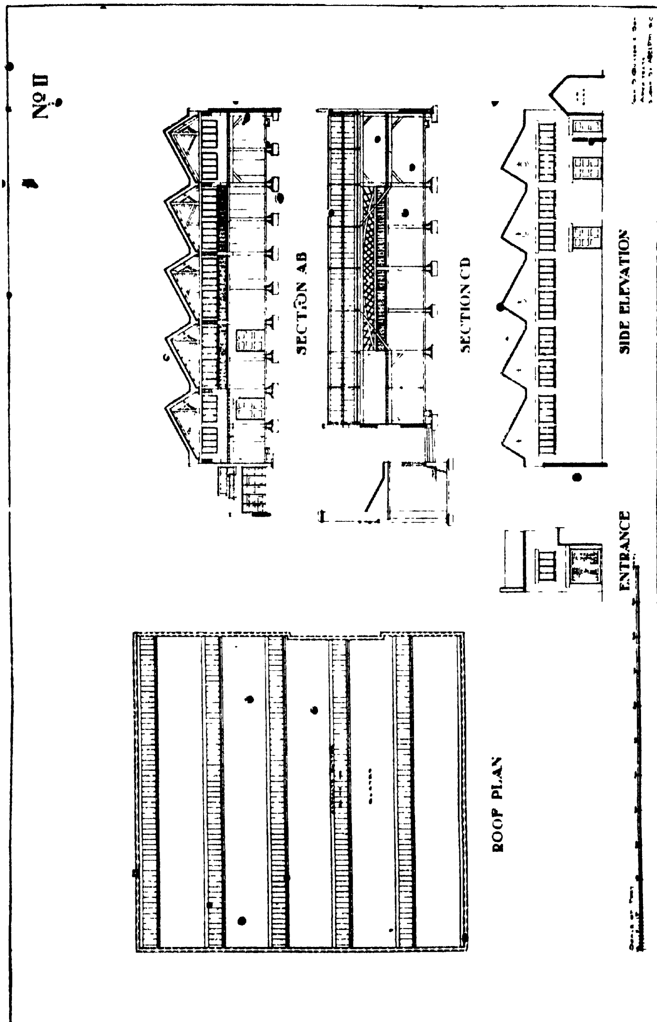


FIG. 78.—A timber-framed factory.

This roof has been designed to serve as a floor should extensions become necessary, and all walls and stancheons are calculated to carry

such extra loads. Seven of these floors are cantilevered out over the river for 6 ft. beyond the lower floors, and the shelters for barges are

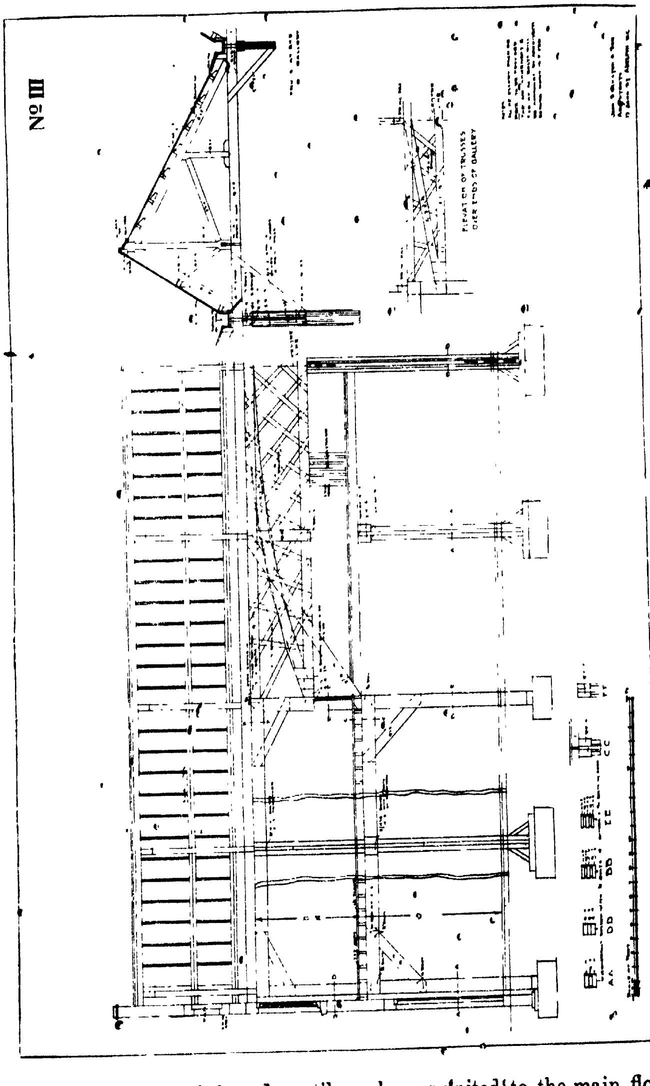


FIG. 79.—A timber-framed factory.

also carried on reinforced cantilever beams, united to the main floor beams and extending 15 ft. beyond the 6 ft. already mentioned. The

purlins for carrying the glazing to these shelters and also the cantilevers on the street side of the building are of reinforced concrete construction.

FIG. 80.—Boot warehouse, Pentonville Road, London. (A. Sykes, F.R.I.B.A., Architect.)

The first floor possesses an interesting feature in that it was desired to omit one of the stancheons to give a large clear unobstructed office. This was done by forming a truss on floor over and thus

transferring the load from four floors above to the piers at sides which run direct to basement.

The architects for the work were Messrs. W. & G. Higginbottom

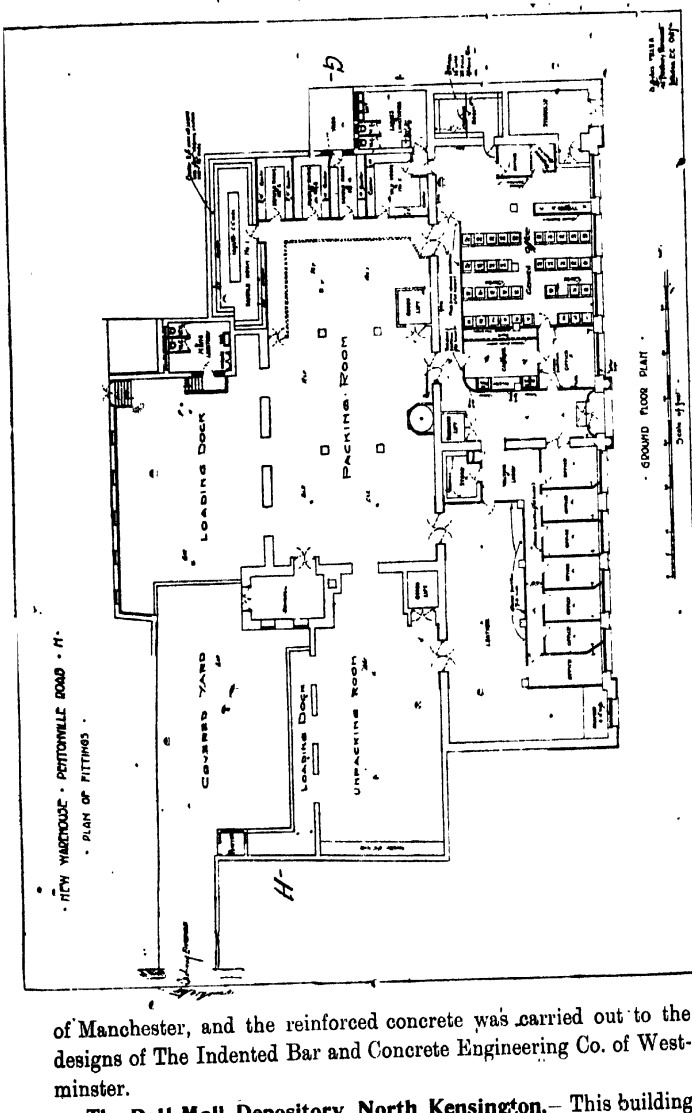


FIG. 81.

of Manchester, and the reinforced concrete was carried out to the designs of The Indented Bar and Concrete Engineering Co. of Westminster.

The Pall Mall Depository, North Kensington.— This building

is designed as a complete reinforced concrete frame, and every floor is constructed as a separate building in itself.

The staircase and lift giving access to them are kept free from the

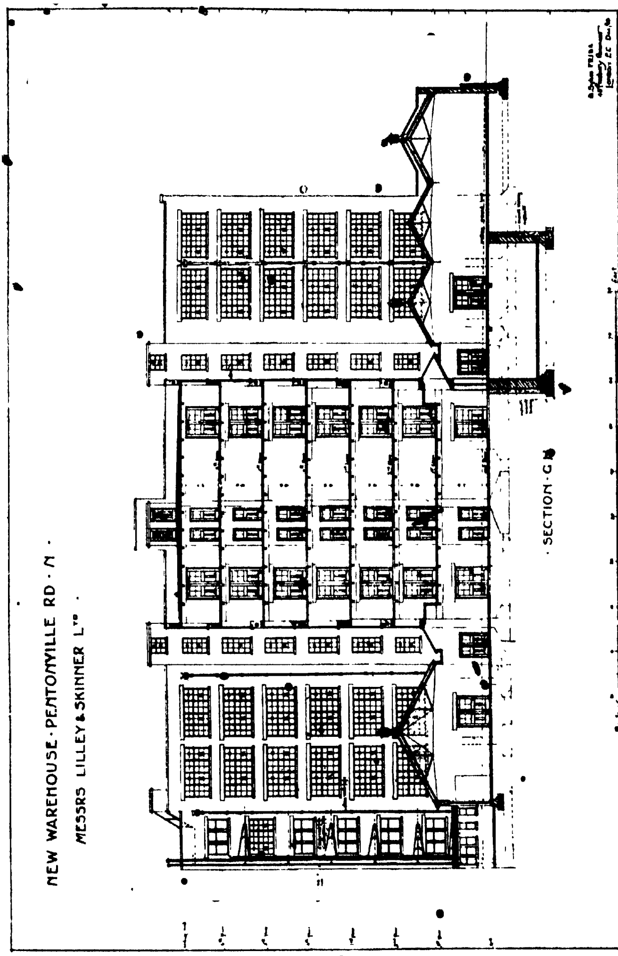


FIG. 82.

parts used for storage, and this elimination of the stairs and lift-wells running from bottom to top of building greatly obviates the risk of fire spreading from one floor to another.

How great this danger is may be appreciated from the fact that

the fire insurance companies have regarded each floor of each block as a separate structure, thereby enabling them to accept a rate very considerably below the normal; not only for the building itself, but for the whole of the contents stored therein. The building consists of two blocks 100 ft. by 36 ft. 6 ins. and 100 ft. by 42 ft. respectively, with an open area 35 ft. 6 ins. wide between them. In this area are placed the staircase and lifts, and bridges of fire-resisting construction 12 ft. 6 ins. wide lead from them to the floors of depositories. Double iron doors cut off each of these units from the bridges themselves, and as a further means of safety hydrants are placed at each floor level upon the bridges.

The architect for the work was Mr. W. G. Hunt, F.R.I.B.A., of 57A Cromwell Road, and the whole of the reinforced concrete work was carried out in accordance with the system of The Considère Construction Co. of Westminster.

Factory for Messrs. Carraras, City Road, E.C.—This building, except for the external and party walls, is entirely of reinforced concrete construction, and consists of basement, ground, and three floors over. It is a striking example of the speed with which reinforced concrete construction can be carried on, for the building was carried from basement to roof in less than ten weeks. As each of the five floors covers an area of some 11,200 sup. ft., the execution of the work at the rate of fourteen days per story is a refutation of the critics who hold that the use of reinforced concrete causes delay in building operations.

The general lay-out is shown by the plan (Fig. 75), and it may be of interest to state that all piers and supports have been designed and erected of sufficient strength to carry future floors.

The architects for the work were Messrs. Hobden & Porri of Finsbury Square, and the reinforced concrete work was carried out to the designs of Messrs. L. G. Mouchel & Partners of Victoria Street, Westminster.

A Timber-framed Factory.—This building was designed to be erected entirely of timber, and Fig. 79 shows full details of type of construction adopted.

The external walls were of old brickwork, and were raised to keep out weather, but the whole of the weights of building and machinery were to be carried by the built-up timber posts placed against walls and at edge of gallery.

The architects for the work were Messrs. John S. Quilter & Son of 13 John Street, Adelphi.

Boot Warehouse, Pentonville Road, London.—This building

was erected for Messrs. Lilley & Skinner, Ltd., and is situated on the north side of Pentonville Road. As will be seen from the plan, the building covers an area of about 21,000 sup. ft., and consists of basement, ground, and five floors over.

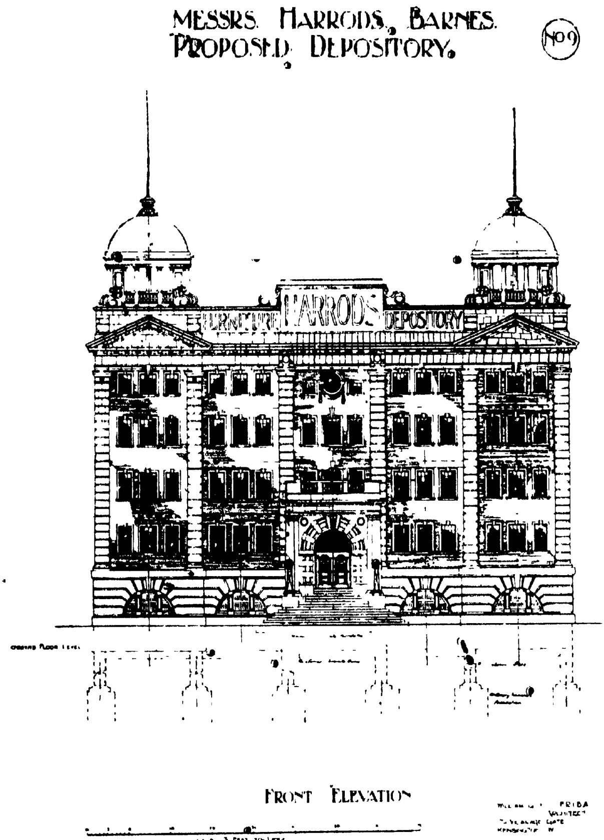


FIG. 83.

Externally the building is of brick and stone, but otherwise the whole of the structure is of reinforced concrete.

The architect for the work was Mr. A. Sykes, F.R.I.B.A., of Finsbury Pavement, E.C., and the concrete work was carried out to the designs of Messrs. L. G. Mouchel & Partners of Westminster.

Messrs. Harrods Depository, Barnes.—This building was

erected for Messrs. Harrods of Brompton Road, and is but the central block of what will be one of the largest depositories in this country.

The building at present consists of ground and four floors over, and except for brick and stone wall fillings is entirely of reinforced concrete

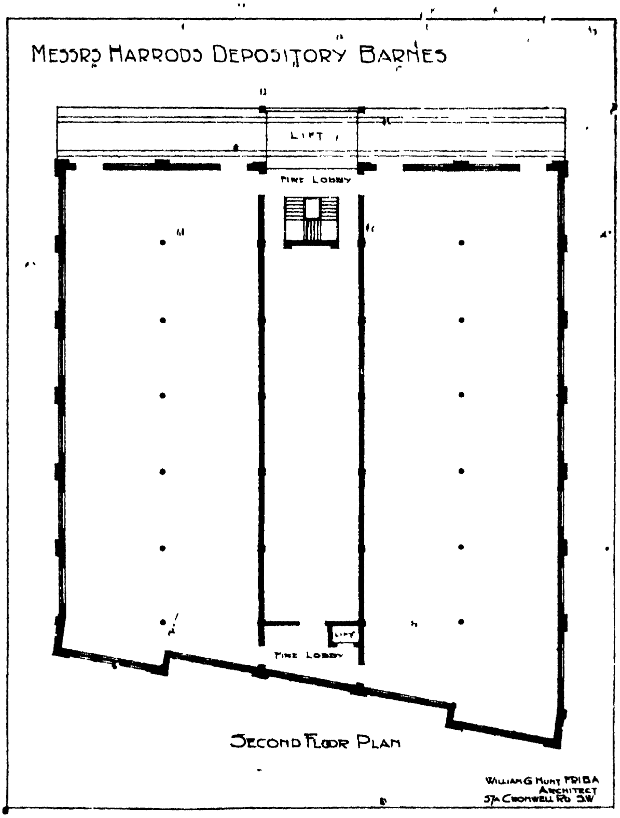


FIG. 84.

construction. It measures approximately 100 ft. × 112 ft., and is divided into three separate and distinct buildings on each floor, and a reference to plan (Fig. 84) shows the general arrangement and placing of fire lobbies, lifts, and staircase. The most noteworthy features of the structure are the large lift and the cantilevered galleries at rear, which are shown in Fig. 85. This lift runs the whole height of

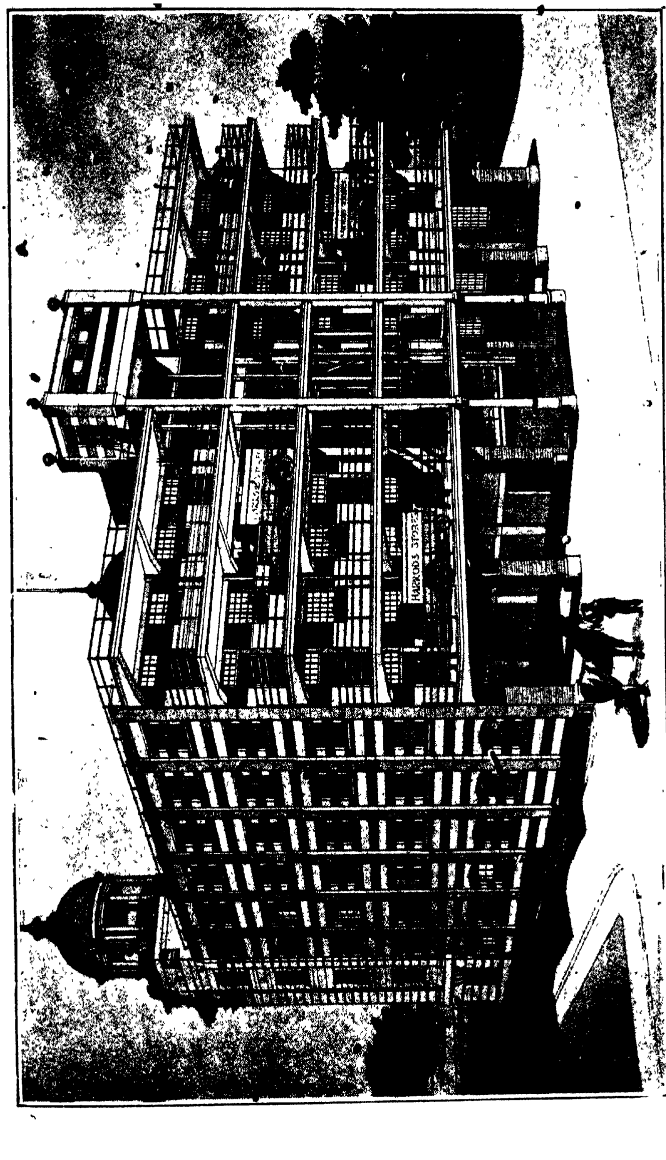


FIG. 85.—Messrs. Harrods' Depository, Barnes. (W. G. Hunt, F.R.I.B.A., Architect.)

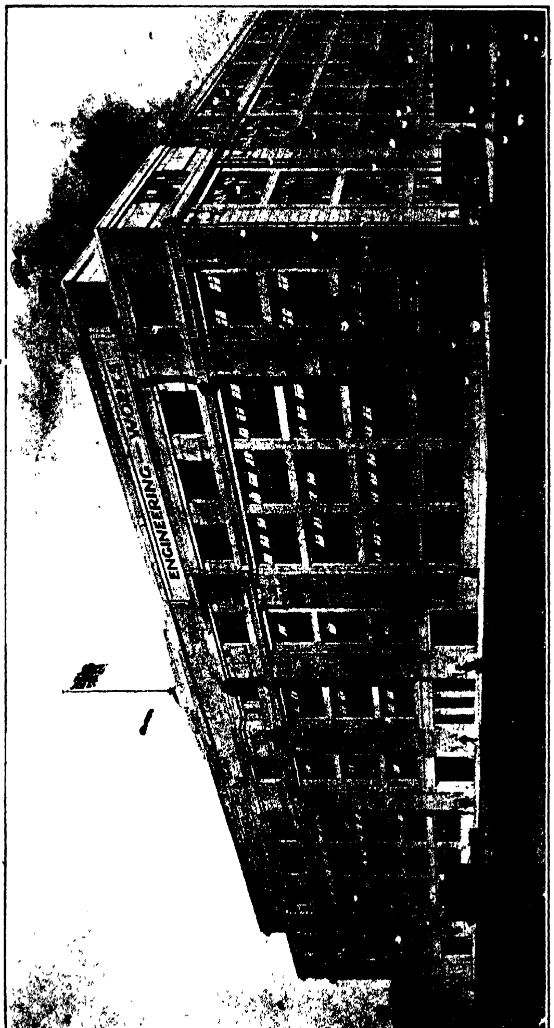


Fig. 86.—The Tilling-Stevens Engineering Works. (Wallis Gilbert & Partners, Architects.)

building and allows the removal vans to be elevated to the floor to which goods are to be stored. The architect for the building was Mr. W. G. Hunt, F.R.I.B.A., of 57A Cromwell Road, S.W.

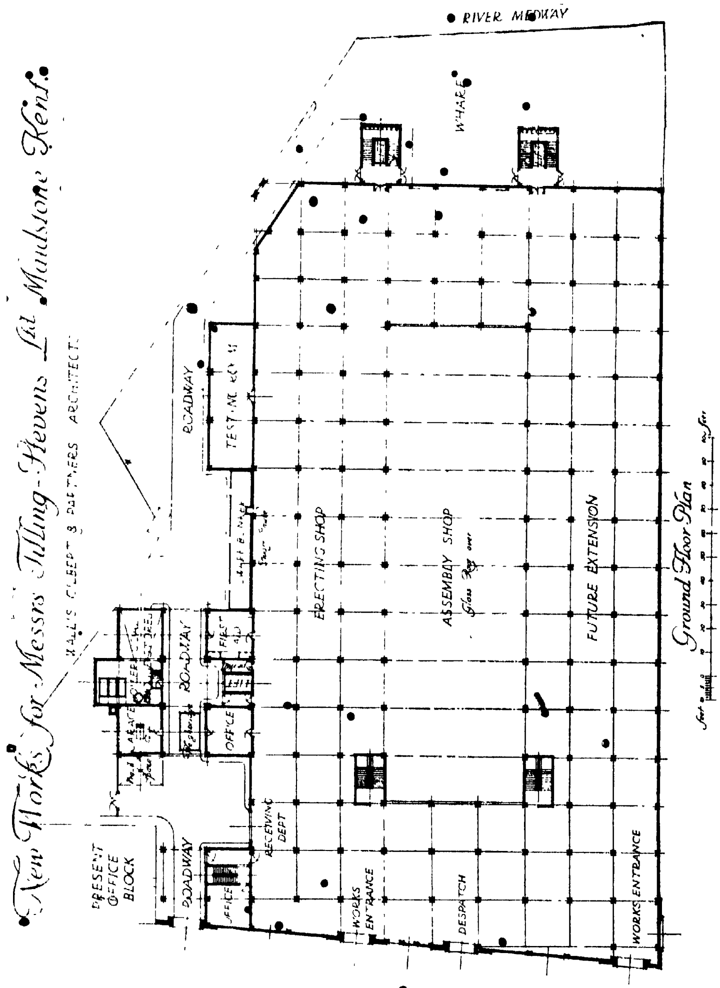


FIG. 87.

The Tilling-Steven Engineering Works, Maidstone, Kent.—This building has been but recently completed, and Fig. 87 shows the general lay-out of the whole structure, from which it will be seen that it is planned on the unit sytsem.

The building stands on a site between the public road and the river, thus allowing the possibility of using both land and water transport. A roadway passing over a weighbridge runs along one side to the wharf at rear and a large bay is provided for unloading.

The coal stores, boiler house, and a private garage are placed on

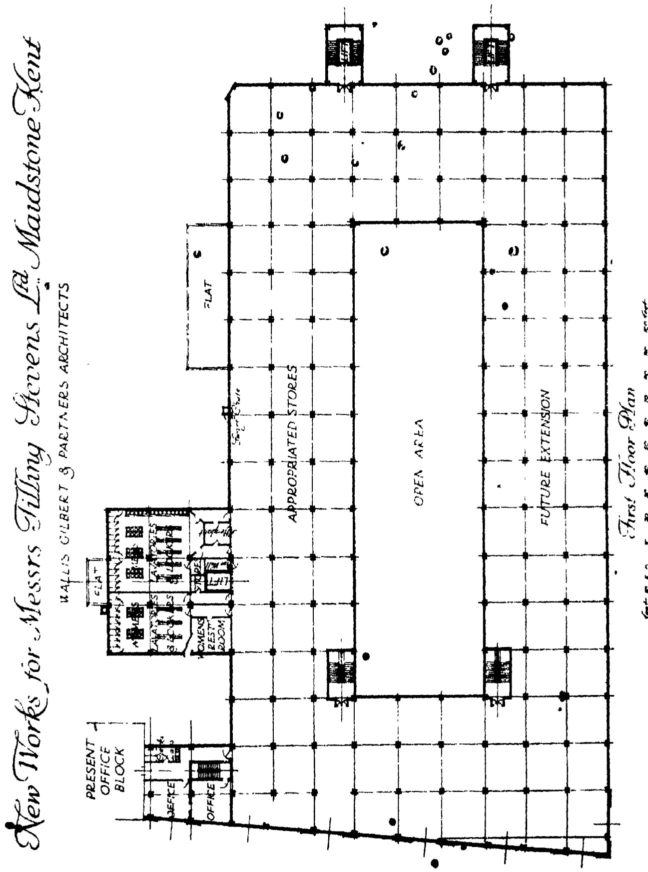


FIG. 88.

one side of this roadway, and offices, lift, etc., on the side abutting the factory. On the first floor these, together with the space occupied by the roadway, are carried up as adjuncts to the main block, and on alternate floors serve as first-aid rooms, rest-room for women, and lavatories for both sexes.

The general disposition of the factory block is as follows :—

Ground Floor.—Receiving, testing, and despatch departments, with

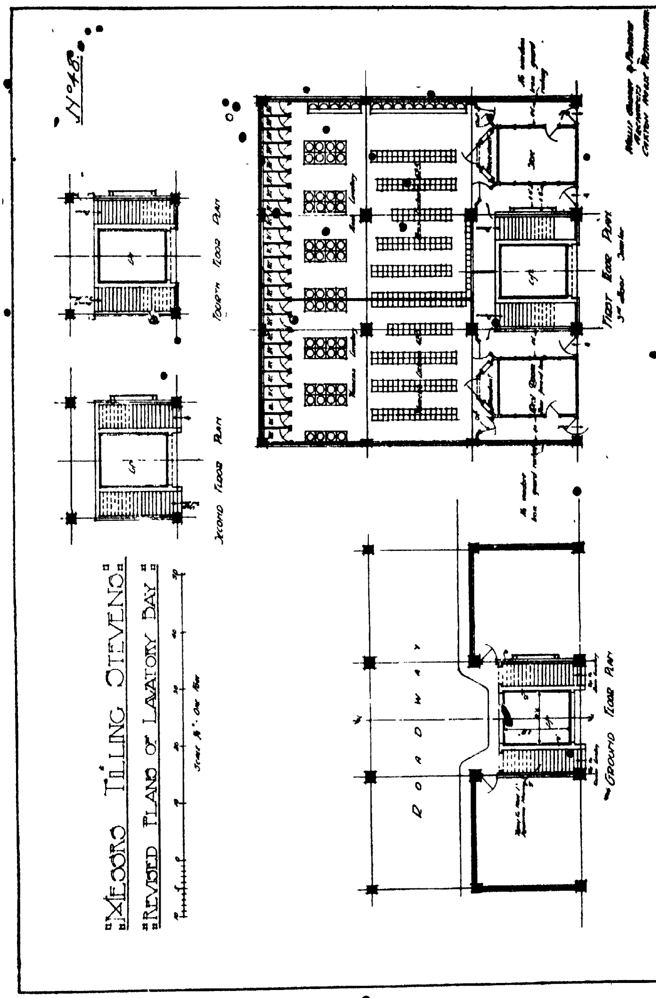


FIG. 89.

time-keeper's offices, etc. These take but a small proportion of the whole, and the remainder is occupied by assembly shop.

First Floor.—Fitting shop and lavatory annexe.

Second Floor.—Partial assembly shop, appropriated store, etc.

Third Floor.—Machine shop and lavatory annexe.

Fourth Floor.—Machine shop and messrooms.

In all floors brackets have been formed during the reinforced con-

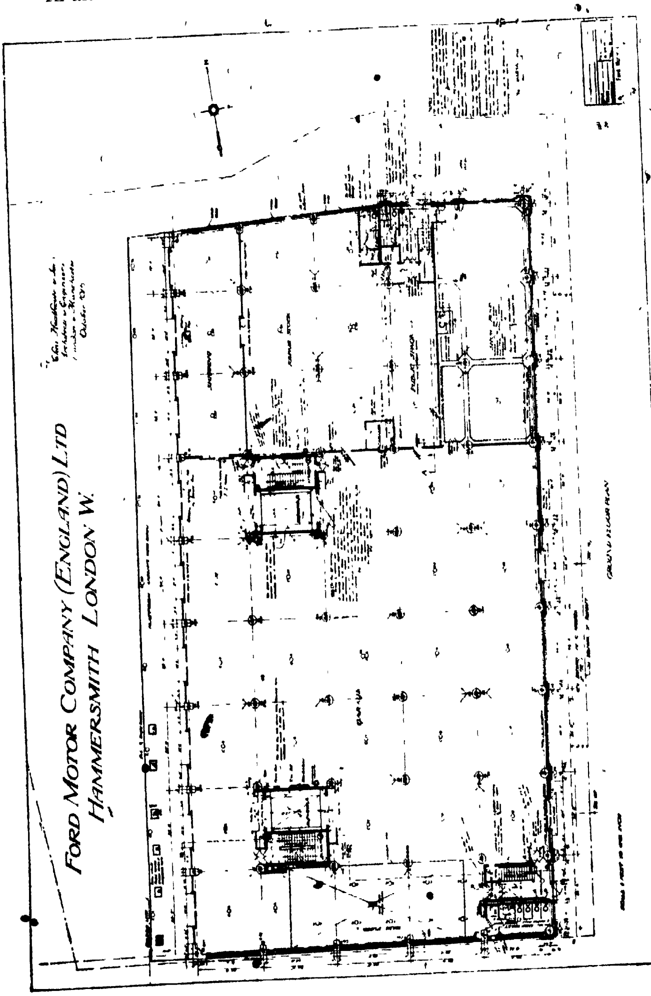


Fig. 90.

struction, and beams have been arranged so that the pulley wheels are close up to the underside of the floors, in order to give as much clear headroom as possible.

A reference to the elevation shows that the maximum daylight

lighting has been provided, and whatever artificial light is required will be by electricity

Ample staircases are provided, and as will be seen from the plan,

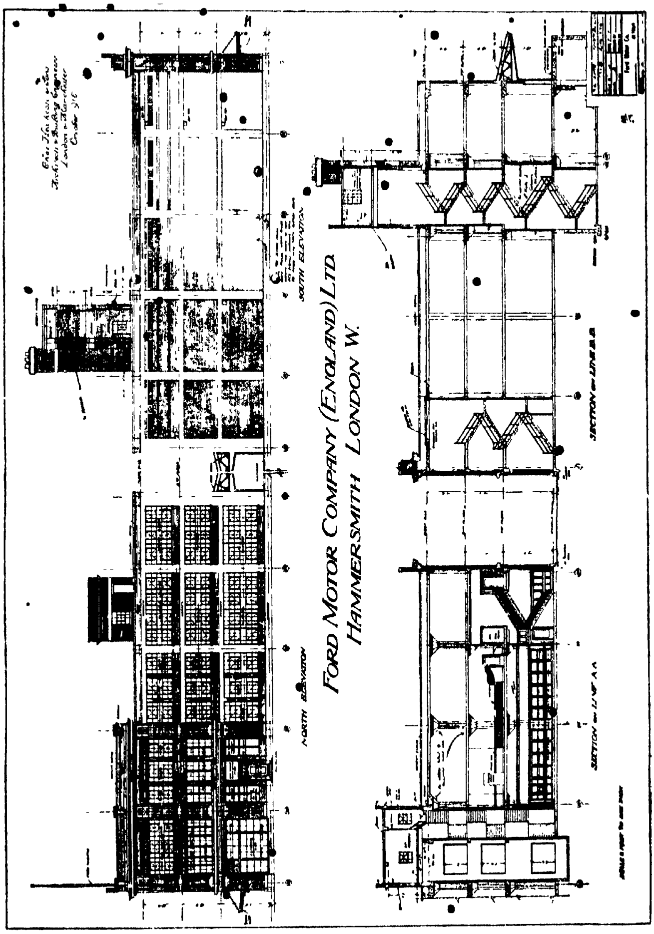


FIG. 91.

the employees have three alternative means of escape should a fire break out at any point in the building.

All lavatory walls are finished with white glazed tiles, and great care has been taken to make the sanitary arrangements scientifically up to date.

The architects for the building are Messrs. Wallis Gilbert Partners of Caxton House, Westminster, and the whole of the reinforced concrete has been designed by The Trussed Concrete Steel Co. of Westminster.

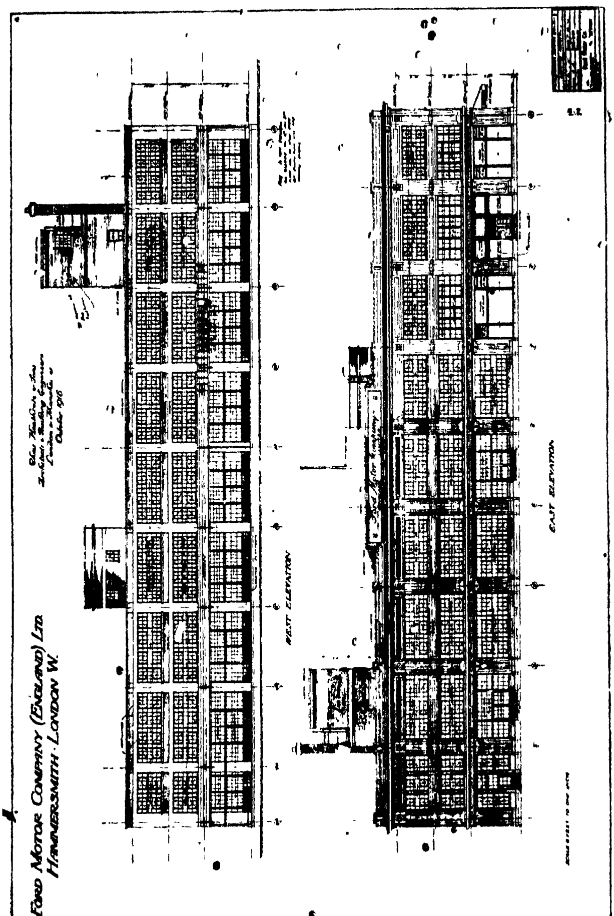


Fig. 92.

The Ford Motor Works, Hammersmith.—This building has been lately erected as the London head-quarters of the Ford Motor Co., and is entirely of reinforced concrete construction.

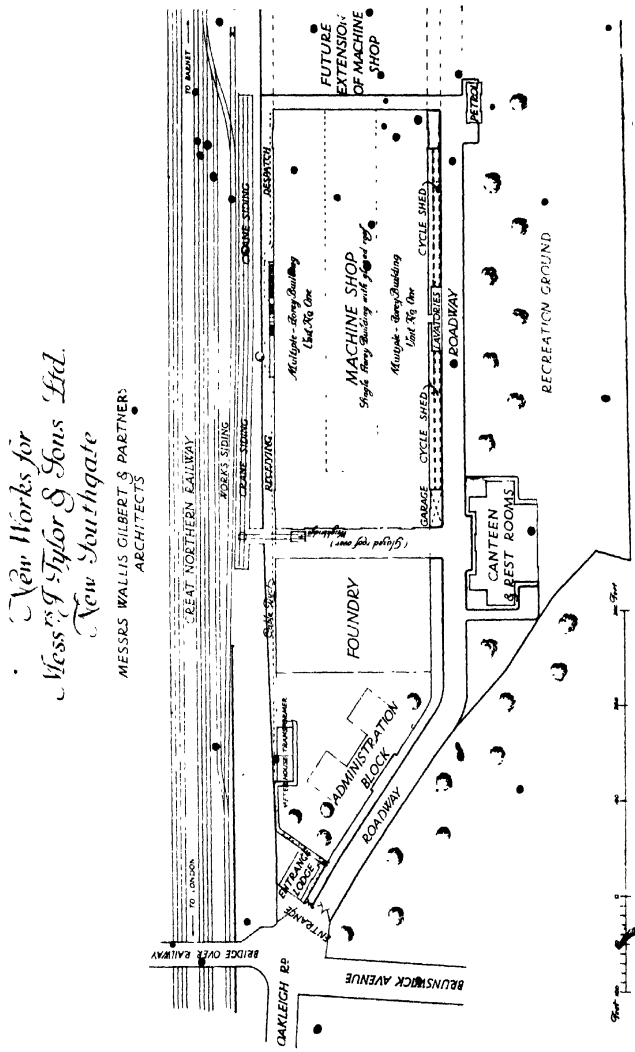

New Works for Messrs. J. Taylor & Sons Ltd. New Southgate
MESSRS WALLIS GILBERT & PARTNERS ARCHITECTS
GREAT NORTHERN RAILWAY
WORKS SIDING
CRANE SIDING
TO BARNET
TO LONDON
BRIDGE OVER RAILWAY
OAKLEIGH RD
BRUNSWICK AVENUE
ENTRANCE
ENTRANCE LODGE
ADMINISTRATION BLOCK
ROADWAY
FOUNDRY
MACHINE SHOP
RECEIVING
DESPATCH
CYCLE SHED
LAVATORIES
GARAGE
ROADWAY
FUTURE EXTENSION OF MACHINE SHOP
PETROL
CANTEEN & REST ROOMS
RECREATION GROUND

FIG. 93.

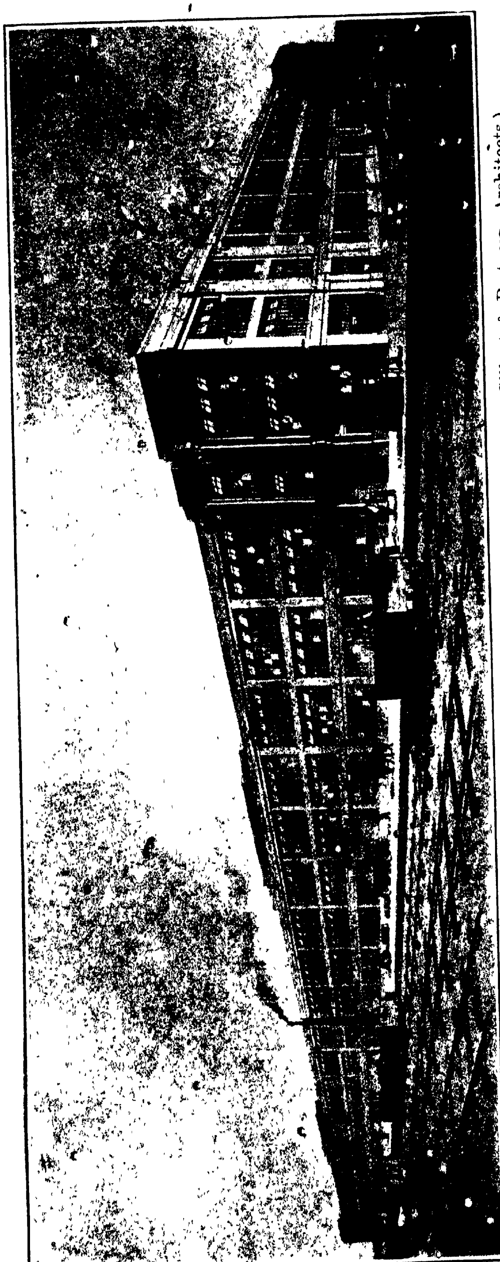


FIG. 94.—New works for Messrs. J. Tylor & Sons, Ltd., New Southgate (Wallis Gilbert & Partners, Architects.)

The front elevation and part of one of the return walls are faced with red brick and artificial stone dressings, whilst the southern wall

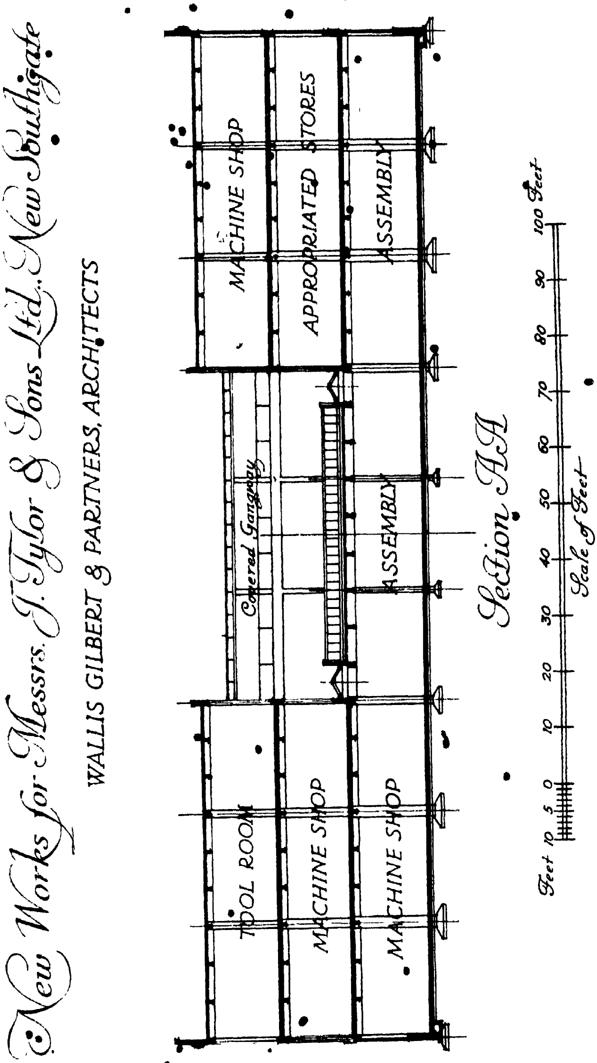


FIG. 95.

has red brick panels filled in between the constructional members, but otherwise the reinforcement work is left showing.

The building as erected is but a portion of the completed scheme which will consist of five stories and the supporting piers, and foundations have been designed and constructed to carry the future loads that will come upon them.

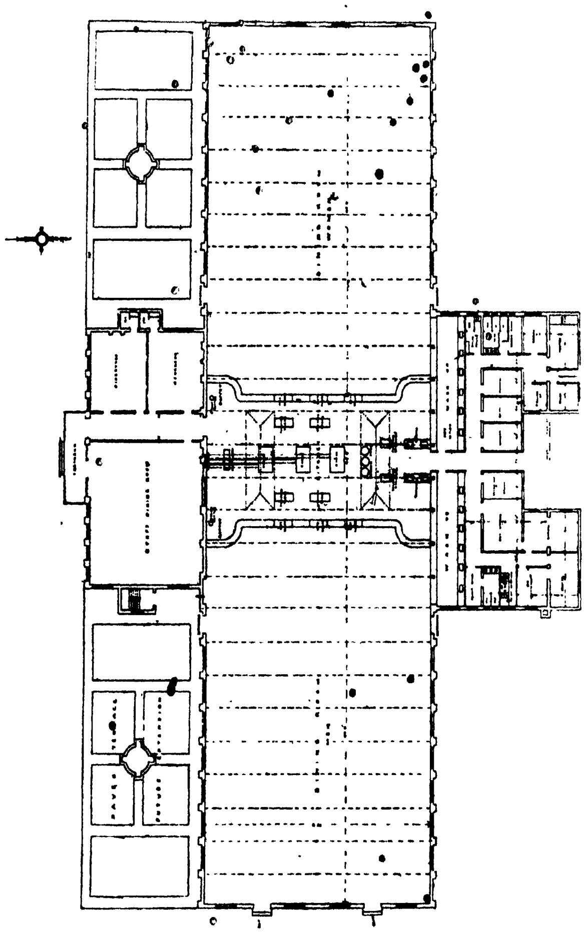


FIG. 96.—Canteen for large aircraft works. (H. W. Matthews, M.S.A., Architect.)

The building is approximately 224 ft. by 122 ft., exclusive of the loading platform at rear, and is planned on a unit system of 25 ft. by 25 ft. bays, thus dividing the structure into 45 divisions.

The ground floor is occupied by garage and repair shop, but at

north-east corner, a well-lit showroom and the entrance to offices is provided. These latter occupy a part of the first floor, where are also the welfare rooms and the first-aid rooms, but otherwise the remainder of the upper story is used as machine and repair shops.

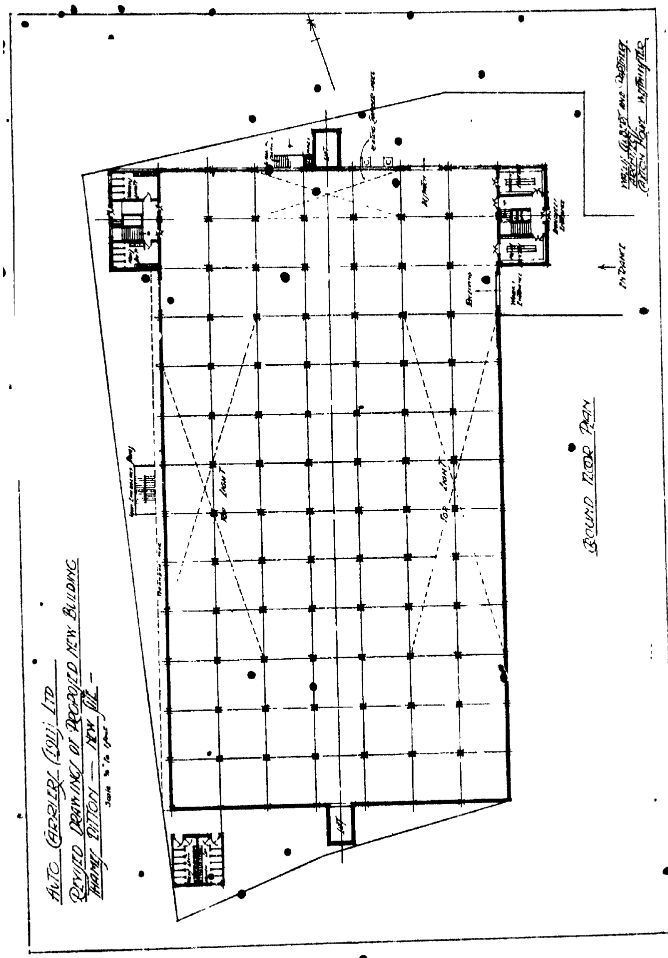


FIG. 97.

Two large electric lifts are provided to take cars from one floor to another, and on ground floor a large washing space is provided in the garage.

The heating chamber is in basement, and large bunker space for coal is formed under the loading platform in which six coal shoots are formed to allow the fuel to be delivered direct from railway

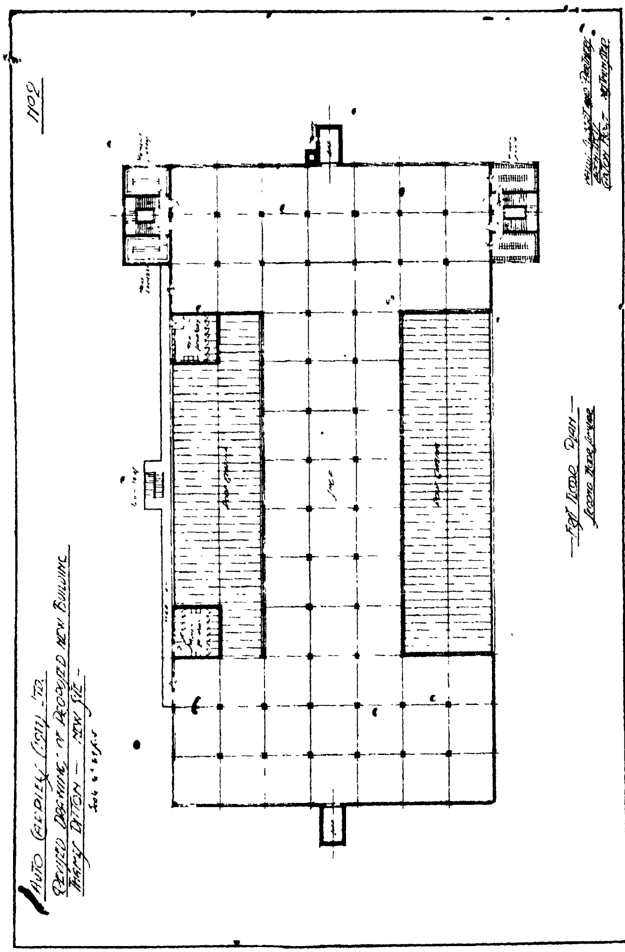


FIG. 98.

waggon to store. This loading platform is 14 ft. wide, extends full length of back elevation, and has a railway siding abutting upon it. It is covered with a glazed roof resting on reinforced concrete cantilevers.

The bulk of the petrol is stored in a concrete underground tank in the yard at north-west of building, and is delivered by the "Bywater" system to the point required. For the purpose of charging the cars, one bay on front elevation has been enclosed, and forms a self-contained dock with armoured doors between it and the garage, and should therefore any car fire during filling the outbreak is localized to one bay.

The architects, who also designed the whole scheme for the re-inforcement, are Messrs. Chas. Heathcote & Sons of Manchester.

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